S·A·E JOURNAL

ANNUAL MEETING

S·A·E

FEBRUARY 1931

The Relative Action Between Frame and Axles

—*Probably the Second Fastest Action in Connection with a Motor Car*

AND yet, we have been trying to control this action with hydraulic mechanisms . . . ¶ Do you know of another single instance where any hydraulic apparatus has been called upon to do work in other than slow duty? For example—presses, lifts, jacks, etc., etc. . . . ¶ In spite of there being no precedent, no design to copy or follow, an hydraulic apparatus has now been perfected which is capable of meeting any degree of flash action and *controlling* it . . . ¶ The new Watson Hydraulic Stabilator, by the introduction of Supercharging, meets and controls any speed of relative action between frame and axles and thus insures full stability and safety regardless of whether the car is travelling twenty miles an hour, fifty miles an hour, eighty miles an hour or one hundred miles an hour . . . ¶ We shall be glad to have you write us for full particulars as to the construction and operation of these new and unique shock absorbers.

JOHN WARREN WATSON COMPANY
Philadelphia, Pa.

J. W. Watson
President

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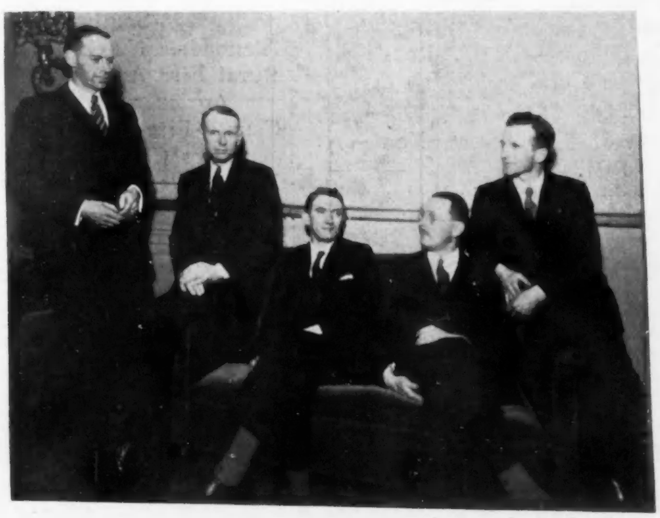
CONTENTS

Annual Meeting Reveals Much Progress

All Sessions Uniformly Well Attended During the Five Days Meetings Started on Time and Run on Schedule Thursday Dinner a Huge Success

THIS YEAR'S Annual Meeting was pronounced by many to be the best in the history of the Society, and it loses no luster by comparison with the Annual Dinner that so auspiciously opened the new year in New York City on Jan. 8. More than 950 members and guests registered for the technical sessions, and the attendance at the dinner on Thursday evening was more than 700. All of the 17 sessions were uniformly well attended by from 100 to 325. There were no slim sessions, a fact that showed the great diversity of interests of the Society's membership, since all the Professional Activities were represented on the program by one or more sessions.

Nobody was forced to lose time waiting for a session to start nor had occasion to become impatient through the dragging out of a session beyond the set time, as the sessions were run by traffic-light control, which seemed to have a psychological effect so that no officer was called upon to enforce its edicts, with one exception—the Detonation Session. Restriction of the number of papers to one or two at each of the other sessions and limitation of time for their presentation resulted in a wealth of prepared and impromptu oral discussion that brought out much valuable supplemental information. The Detonation Session, which was the most largely attended, had to be run by a minion of the law so that the 17 papers could be presented within the allotted time.



BRITISH OIL ENGINEERS DELEGATED BY THE INSTITUTE OF PETROLEUM TECHNOLOGISTS TO ATTEND THE MEETING TO PRESENT A PAPER ON KNOCK RATING OF FUELS

(Left to Right) A. W. Pope, Jr., and T. A. Boyd, of the Cooperative Fuel Research Steering Committee; C. H. Barton, C. H. Sprake and R. Stansfield, of the Standardization Subcommittee of the Institute of Petroleum Technologists, of England

Another noticeable result of starting and ending the sessions on schedule was that, after the conclusion of each, fully one-half of those in the room remained for half an hour or more to gather in groups for continued informal discussion of the subject. These contacts often are worth almost as much to members as are the papers and discussion presented formally in the meetings.

Papers Show Progress Made

Real progress in the fields of research on fuels in air-cooled and Diesel or oil engines, in lubricants, in chassis-vibration reduction and in riding-qualities was revealed, and it was evident that the members and others

Meetings Calendar

National Meetings of the Society

19th National Aeronautic Meeting—April 15 and 16
Book-Cadillac Hotel, Detroit

Production Meeting—April
Milwaukee; Sponsored by the Milwaukee Section

Summer Meeting—June 15 to 19
White Sulphur Springs, W. Va.

20th National Aeronautic Meeting—Sept. 1 to 3
Hotel Statler, Cleveland
In Conjunction with National Air Races

February Section Meetings

Buffalo—Feb. 3
Hotel Statler; Committee Dinner 6:30 P.M.
Engineering Features of the 1931 Automotive Vehicles—Austin M. Wolf, Consulting Engineer

Baltimore—Feb. 6
Lord Baltimore Hotel; Dinner 6:30 P.M.
Driving at Night—W. M. Johnson, Commercial Engineer, National Lamp Works

Canadian—Feb. 18
Royal York Hotel, Toronto
Relation of the Employe to the Management—V. M. Smith, Works Manager, Continental Motors Corp.

Cleveland—Feb. 9
Hotel Statler; Dinner 6:30 P.M.; Entertainment
Is Cutting Corners in Business Justified?—Dale Brown, Cleveland Better Business Bureau
Can the High-Speed Diesel Engine Compete with the Gasoline Engine?—H. D. Hill, Vice-President, Hill Diesel Engine Co.

Dayton—Feb. 10
Joint Meeting with the Engineers Club of Dayton
An Airplane Trip from the City of Washington, to Buenos Aires and Santiago—Capt. A. W. Stevens, Wright Field

Detroit—Feb. 23
Book-Cadillac Hotel; Dinner 6:30 P.M.
Body Division Meeting, Speaker, Theodore F. MacManus

Indiana—Feb. 12
Hotel Severin, Indianapolis
Review of the Automobile Shows—D. G. Roos, Chief Engineer, Studebaker Corp.

Metropolitan—Feb. 18
A.W.A. Club House, 357 West 57th Street, New York City; Dinner 6:30 P.M.
The Body Designer's Viewpoint on Aerodynamics, Based on Wind-Tunnel Tests at the University of Detroit—Julio Andrade, Murray Corp.
Streamline Automobile Bodies—Wolfgang Klemperer and O. K. Marti, Goodyear-Zeppelin Corp.
Construction and Performance of the Bluebird—Capt. Malcolm Campbell, of London

Metropolitan—Feb. 25
Second Annual Greater New York Safety Conference, in cooperation with other National and Local Organizations
Pennsylvania Hotel, New York City
Commemorative Aeronautic Meeting; in conjunction with six other National Organizations
Engineering Societies Building, New York City; 8 P.M.

Milwaukee—Feb. 4
Milwaukee Athletic Club
Free-Wheeling—H. E. Churchill, Research Department, Studebaker Corp. of America

New England—Feb. 10
Hotel Kenmore, Boston
Cold-Starting and Oil-Pumping—Dr. A. E. Becker, Standard Oil Development Co.

Northern California—Feb. 17 and 18
St. Francis Hotel and Civic Auditorium. The Section is sponsoring two sessions of the Western Metal Congress.

Northwest—Feb. 6
New Washington Hotel, Seattle, Wash.
Steel—C. C. Finn, John Finn Metal Works

Oregon—Feb. 12
Multnomah Hotel, Portland; Automobile Show Dinner 6:30 P.M.; Entertainment
The Trend of Automobile Design for 1931—Prof. F. G. Baender, Oregon State College

Philadelphia—Feb. 11
Philadelphia Automobile Trade Association, Dinner 6:30 P.M.; Entertainment
Effect of Legislation on Truck Design in Relation to Load Distribution and Vehicle Width—L. R. Buckendale, Timken Detroit Axle Co.

Pittsburgh—Feb. 26
Steering Symposium

Southern California—Feb. 6
Alexandria Hotel, Los Angeles
Rural Fire Apparatus—J. P. Fairbanks, College of Agriculture, University of California
County Fire Apparatus—W. E. Powelson, Los Angeles County
Metropolitan Fire Apparatus—W. P. Akers, Seagrave Corp.

St. Louis—Feb. 10
Hotel Statler; Dinner 6:30 P.M.; Entertainment
Modern Automobile Design Symposium

Syracuse—Feb. 3
Hotel Syracuse; 8:00 P.M.
Air-Cooled-Cylinder Development—Carl T. Doman, Research Engineer, H. H. Franklin Mfg. Co.

Washington—Feb. 18
Subject—Hydrogenation

Wichita—Feb. 12
Green Parrot Inn
The Gluing of Wood in Aircraft Construction—Mr. Truax, Forest Products Laboratory

who were present at the various sessions carried home a great many valuable ideas that will be reflected later in many directions.

The Society owes a debt of gratitude to the authors for the preparation and presentation of so many very interesting and informative papers and also to the numerous discussers who contributed so much well-informed written and oral discussion on the numerous topics. The Chairmen and members of the Meetings Committee and the Professional Activities Committees are deserving of great credit for the excellence of the program and the selection of timely subjects and well-qualified speakers.

From start to finish the entire meeting ran smoothly, with strict adherence to the program and no disappointments or hitches.

Detroit Section Host to Multitude

The Annual Meeting Dinner on Thursday evening, at which the Detroit Section was host to the Society and its guests, was a highlight of the meeting. The number seated at the dinner was 725, and many more came in later to hear the addresses by Mayor Murphy, of Detroit; Vincent Bendix, the new President of the Society; and Larry A. Hawkins, of the General Electric Co. The scientific talk by Mr. Hawkins on the marvels of atoms, electrons and ions was commented upon as the sort of address well suited to an S.A.E. dinner.

If any dissatisfaction was felt regarding the meeting it was based on the three-ring-circus nature of the affair that prevented some from attending all the sessions in which they were interested. Simultaneous sessions had to be held on three forenoons, and a score of committee meetings were held on the five days. Some of the committee meetings lasted for 3 hr. or more, keeping the committee members from some of the sessions. As a result of these committee meetings, however, the programs for a great deal of constructive work for the year have been outlined so that the new committees appointed, as announced in this issue of the S.A.E. JOURNAL, can start work promptly.

In the following pages is given a full account of the meeting, session by session, together with reports of the committee meetings, the election of officers to serve through 1931, election of Nominating Committees to select nominees for Vice-Presidents, and the appointment of Administrative, Professional Activities, Standards, Research and special Committees for the year. Reports of the several committees for last year are also contained in this issue.

Such of the Annual Meeting papers as are not published in this number of THE JOURNAL are to be printed, together with discussion, in as early succeeding issues as space, the balancing of the contents of each issue, and other conditions permit.

Lively Air-Cooled-Engine Debate

Opponents and Defense Tilt To Amusement of Large Crowd—Torsional Vibration Discussed

MUCH LAUGHTER and frequent applause punctuated the lively debate on air-cooled engines that put zest into the first real technical session of the 1931 Annual Meeting. This was the Engine Session, which Chairman Alex Taub opened even a minute or two before the scheduled time of 2 p. m. on Monday and kept moving along so rapidly that the traffic signal never once flashed red.

And thereby hangs the tale of an innovation. To make sure that the sessions would be run off exactly on schedule, limiting the time for presentation of each paper so as to allow ample time for discussion, a three-light traffic signal on a high pedestal was installed at the right-hand end of the speakers' table and operated electrically by the Chairman. A green light signalled the speaker to go, an amber light that he had 5 min. left, and a red light for him to cease and yield the floor to another speaker or discusser.

And while on the subject of paraphernalia, it might be mentioned for the information of members who have not been privileged to attend the recent large National meetings of the Society that a lot of equipment is lugged around and operated at these meetings. For instance, the public-address system includes two microphones on the speakers' table and another on a stand by the screen on the wall to the left of the table, so that when a speaker steps over to the screen to explain a slide he can still be readily heard throughout the room. These mikes are connected to a pair of loud-speaker horns mounted high on a standard at the right of the rostrum. In front of the speaker is an illuminated reading-stand shaded from the audience. And on the floor at the extreme right is a large blackboard on an easel for impromptu chalk talks for the purpose of illustrating intricate points.

The Chairman considerately refrained from monopolizing any of the first speaker's time by extensive introductory remarks, hence did not need to flash the red light on himself.

Torsional-Vibration Dampers Discussed

The two papers presented are printed in full in this issue of the S.A.E. JOURNAL, so the reader may be spared the tedium of summaries here. The first was on Torsional-Vibration Dampers, by J. G. Baker and D. T. DenHartog, and was summarized briefly by Mr. Baker in a running explanation of the slides shown.

The Crystal Room of the Book-Cadillac was filled to the capacity of the chairs by an attendance of about 200. Written discussion of the paper was presented in person by T. C. Van Degrift, of the General Motors Corp. Research Laboratories, and by C. E. Summers, research engineer of the Oakland Motor Car Co. In addition, half a dozen men in the assemblage rose to offer impromptu comment on the subject of torsional-vibration investigation.

In his prepared discussion Mr. Van Degrift told of investigations made at the General Motors Corp. Research Laboratories into the effectiveness of both the Lanchester and dynamic types of vibration dampers and said that the dynamic type gives the better performance, as the vibration amplitudes of the crankshaft are lower for the same size of inertia weight and less dampening is required. The damped dynamic type of vibration absorber is also simpler to adjust and permits the damping to be held constant throughout the speed range of the engine without interfering to a great extent with the effectiveness of the damper. The trend, he said, is toward engines with smaller exciting forces to produce torsional vibration and toward an increase in the number of cylinders, which makes the fitting of dampers to engines much easier. The six-cylinder in-line engine is particularly difficult to fit with a damper that will cope with the third-order inertia-torque period, but in engines having a larger number of cylinders the inertia torques are much smaller.

Damped Dynamic Absorber Best

Mr. Summers, in his discussion, referred to an address he made on the subject of torsional vibration at an Annual Meeting of the Society several years ago and remarked that this form of vibration became a problem with the first steamships having multiple steam-engines and a screw propeller. It came up again with the advent of the synchronous electric motor, and Alexander Churchward at that time designed a friction-type damper and a reaction or dynamic-type damper. Later the problem was to adapt these two types to the characteristics of the internal-combustion-engine crankshaft. A considerable amount of work has been done, he said, on the reaction type by

the General Motors Corp. and this type is used on most of its cars, as it is much lighter than the friction type. If this damper is tuned so that it opposes the period of the crankshaft, it cuts down the exciting force that vibrates the damper itself, and when the speed of the critical vibration period is passed through there is nothing to excite the damper and it subsides so that the "tail does not wag the dog."

Mr. Baker agreed with Mr. Van Degrift and Mr. Summers that the same damping effect can be obtained with less inertia with a damped dynamic vibration absorber but said that with the Lanchester the performance can be predetermined with accuracy, whereas with the damped absorber the performance must be determined experimentally. He admitted that the damped absorber is correct for automobile engines. Boris T. Sergayeff, of the General Motors Corp., remarked that investigations had shown that there is not much theoretical difference between the two types and that there was no difficulty in theoretically determining both the mass and the elasticity.

Meeting Divides on Air-Cooling

Mr. Doman's presentation of the paper on the Franklin Air-Cooled Engine resulted in a meeting divided against itself, with Chairman Taub and

MEN WHO WERE PROMINENT AT THE ENGINE SESSION

(Top) J. P. Den Hartog and J. G. Baker, Co-Authors of a Paper on Torsional-Vibration Dampers, Presented by Mr. Baker; Carl T. Doman, Who Presented a Paper by Himself and E. S. Marks on Air-Cooled Engine Development; Dr. H. C. Dickinson, a Discusser
(Middle) Alex Taub, Chairman; L. V. Cram and R. N. Janeway, Who Discussed Air-Cooling versus Water-Cooling
(Bottom) Joseph Anglada, T. C. Van Degrift, C. E. Summers and E. D. Herrick, Who Discussed Air-Cooling and Torsional Vibration

other representatives of the General Motors Corp. and Robert N. Janeway, consulting engineer of Detroit, taking the side of the indirect or water-cooled system, and Thomas J. Lítle, of the Holley Carburetor Co., Joseph Anglada, Dr. H. C. Dickinson and others warmly defending the direct or air-cooled system.

L. V. Cram, assistant chief engineer of the Chevrolet Motor Co., described efforts made eight years ago to develop an air-cooled engine for the General Motors organization and of abandonment of the attempt because of the numerous "bugs" encountered and the desire to obtain, in the words of Mr. Taub, "the greatest value per dollar." He gave Mr. Marks and Mr. Doman great credit, however, for the cooling arrangements developed for the Franklin engine, which he said is the cleverest thing he has seen in a long time. He referred especially to the low power absorption by the fan.

Mr. Janeway's contribution complimented the Franklin engineers, as he said, for their demonstration of the tremendous possibilities for improvement in air-handling efficiency which lie in careful and intelligent investigation, and suggested that the results they had obtained give plenty of food for thought to the water-cooled engineers. He offered criticisms respecting the compression ratio of the Franklin engine, the location of the spark-plug and the absence of detonation which is so contrary to general experience. He also objected to lack of compactness in the design and the cost of production. He said that the future of the air-cooled engine seems to lie in the direction of an increased number of cylinders combined in V form.

Air-Cooled Principle Well Defended

Mr. Anglada remarked that the Franklin organization was to be congratulated upon having stuck consistently to air-cooling and the building of an unconventional automobile. Although prejudiced against air-cooling, he bought a Franklin about a year and half ago, which has been driven about 14,000 miles, principally in the mountains of Pennsylvania, and said he had had more pleasurable driving and less trouble with it than with any of the water-cooled cars he has owned. In shop tests he had found that the engine held compression better throughout the entire length of the piston travel and that he got higher compression than with the water-cooled cars.

Dr. Dickinson also told of personal satisfaction with an air-cooled car, saying that he was much startled to learn how bad the old Franklin engines were, because he had driven one for a long time, and it delivered exceptionally good performance, the valves having run 40,000 miles without regrinding and being in good condition at the end of that time. Without any particular provision for it, the engine warmed up on the coldest day in about 5 to 10 min. and was a little too cool at high speed. He said that it never was known to get too warm in the summer, and the only time the engine knocked was "when the fins got filled up with June bugs that had to be blown out once in two years."

Water-Cooled Engines Not So Hot

Some cracks that provoked hearty laughter were made by Mr. Lítle at the expense of the water-cooled advocates. He remarked that he feared that the Franklin engineers might become discouraged by the remarks of the water-cooled men, and that the Franklin men were not the only engineers who can be criticized for making remarkable improvements after having gone a number of years without them. Water, he said, is not ideal for cooling, and many engines run entirely too cool. As far as cooling is concerned, the air-cooled advocates have the world before them. Failure of the water-cooled engineer to build a successful air-cooled engine should not be disturbing, "because he does not know how to build an air-cooled engine properly." Some idea of the power absorbed by the fan can be determined by removing the fan belt and driving around the Indianapolis Speedway.

The possibilities of air-cooling, said Mr. Lítle, have not yet been touched and we cannot be very proud of the amount of plumbing on the water-cooled engine and of the radiator, the weight of the water carried and the cost of the radiator, water-pump and so on. He predicted that more air-cooled cars will be on the market within the next few years.

Valve Timing Not Objectionable

The question of valve opening and closing was brought up and F. G. Shoemaker, formerly connected with the Franklin company but now with the General Motors Corp. Research Laboratories, expressed high appreciation of the improvements made by Mr. Marks and Mr. Doman in devising a design for compensating for all the variations that come in air-cooled engines. He said that that experience can be looked over most carefully by water-cooled engineers to solve the same problem. The valve timing arrived at is necessary to get high speed, and he said he sees no objection to the timing used and employing a high compression-ratio at the same time.

J. O. Scherer, of the Junkers Corp. of America, also defended the air-cooled principle, remarking that a certain water-cooled car was notorious for blow-by when the engine was hot, and pointed out that water-cooled cars go to many farmers who fill the radiators with hard water, as a consequence of which the water-jacket becomes coated with limestone, which is a heat insulator, and after three or four years the engines knock badly.

E. D. Herrick, of the Lycoming Mfg. Co., poured some oil on the troubled waters by remarking that advantages are to be had in both types of cooling; that fault can always be found with something about the air-cooled engine, but in the final analysis it can be made within reasonable limits as efficient as the water-cooled engine. However, he feels sure that the air-cooled engine is not as economical to produce with present methods as the water-cooled engine.

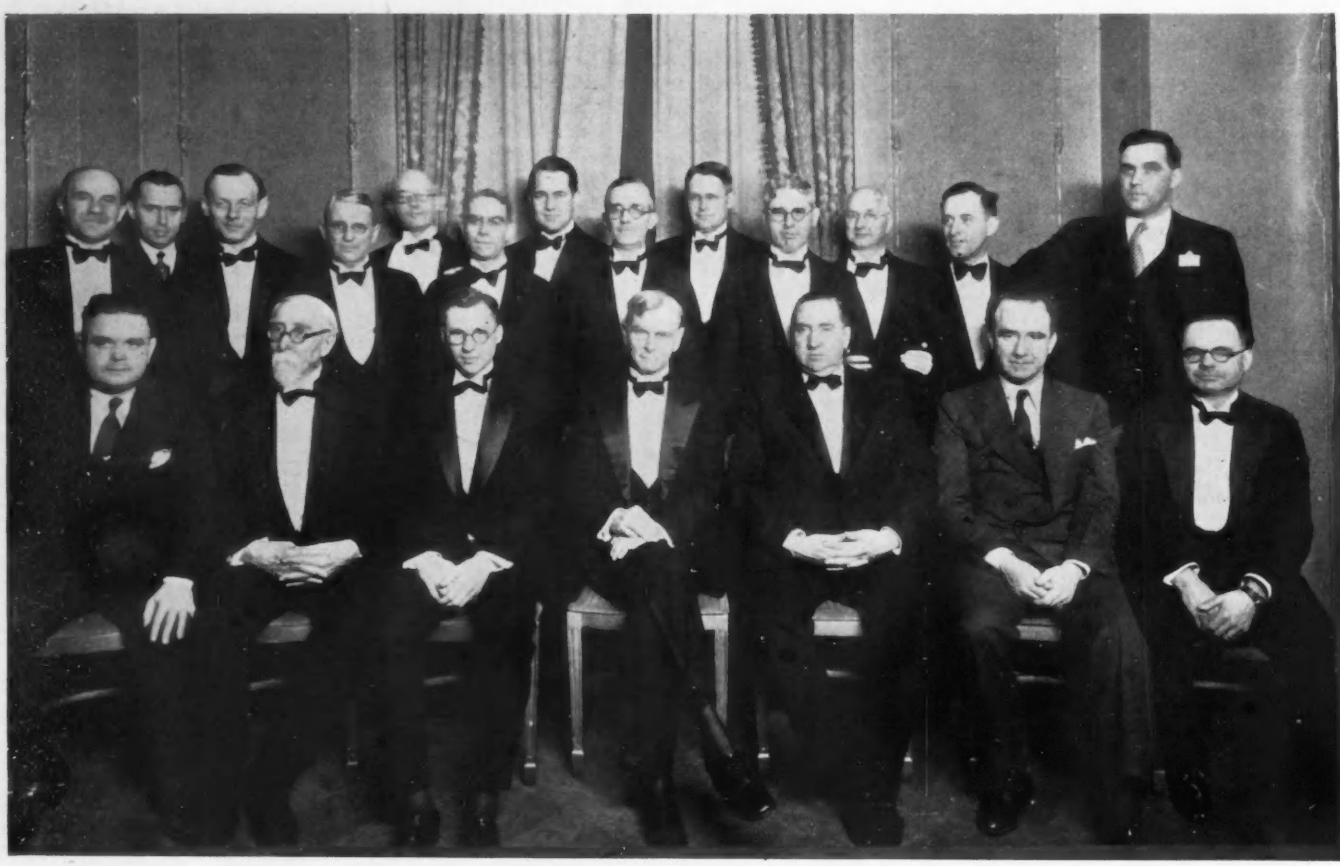
Science and Sociology at Dinner

Physical Marvels Demonstrated for Big Gathering—Mayor Murphy Pleases—Detroit Section the Host

MORE THAN 700 engineers attended the Annual Meeting Dinner on Thursday evening, viewing with surprise and enthusiasm what the *Detroit Free Press* designated as "an eerie demonstration of the higher magic in which the little people of the universe—the ion, atom and electron—were made evident to the human eye and ear through the legerdemain of science."

The guide to the door into this world was Larry A. Hawkins, head of the experimental laboratory of the General Electric Co., of Schenectady, N. Y., who, with his ringmaster of the Lilliputian Circus, Ellis Manning, kept the engineers as interested as if they had been small boys at a three-ring thriller. The actors evident to the eye and ear traveled incognito, although in the laboratory they have been given such names as the ion and the electron.

Digressing for a moment, Mr. Hawkins explained that physics, as he and those who studied it in the '90's knew it, had undergone an almost complete metamorphosis. It was thought at that time, he said, that all of the fundamentals of physics were known, but the very next year something happened which brought about a complete revolution of all of our ideas. Things of which we were absolutely certain in the early '90's, such as conservation of energy, indestructibility, indivisibility, the immutability of the atom, the character of simple wave motion in the ether, absolute space, absolute time, absolute motion, straight lines extending to infinity, the universality of the



SPEAKERS AND GUESTS AT THE ANNUAL MEETING DINNER

(Standing, Left to Right) George L. McCain, Norman G. Shidle, B. B. Bachman, H. W. Alden, J. G. Vincent, William G. Wall, Edward P. Warner, T. J. Litle, J. H. Hunt, David Beecroft, W. R. Strickland, W. Cameron, A. T. Kreusser

(Seated) James Schermerhorn, Jr.; Henry M. Leland, E. L. Manning, L. A. Hawkins, Vincent Bendix, Mayor Frank Murphy, P. J. Kent

law of causation—these had either gone into the discard or been profoundly modified.

Uranium Started a Revolution

The revolution started when the Frenchman Becquerel discovered uranium. This was quite promptly followed by the discovery of radium by the Curies. Uranium and radium are spontaneously changing into lead, giving off helium gas and other radiations. The amount of radioactive material present in the earth is indicated by the amount of helium gas that is present in some of our natural-gas wells. It is also indicated by the fact that everywhere on the face of the earth we find the effect of radioactivity if we look for it carefully enough. Mr. Hawkins, with the assistance of Mr. Manning, then demonstrated the presence of the ions in the air and allowed the audience to hear the arrival of these charged particles at the screen.

Continuing, Mr. Hawkins stated facetiously that radium has a short life and a merry one. "For example, if you had a piece of radium here it would be only 1800 years before half would be turned into lead. Uranium, however, is much more leisurely about it. A piece of uranium would take about 5,000,000,000 years before half would turn into lead. Uranium, therefore, furnishes the best clock we have for measuring the age of the earth. From the uranium deposits scientists can tell from the amount turned into lead how long the earth's crust has been there. The present accepted figure is 1,850,000,000 years."

Electric Eye Shames Human Optic

Continuing their magical experiments, Messrs. Hawkins and Manning performed several surprising experiments with electrons, stating that they can be produced at will in a vacuum tube. The immediate practical result of this knowledge was, of course, the radio. Mr. Hawkins said that there are other methods of producing electrons which are not quite so familiar. One of these is by the photo-electric tube, which in many respects is a superior instrument to the human eye. While the eye cannot see a flicker of a frequency of more than 16 per sec., which fact is taken advantage of in motion pictures, the photo-electric eye is 100,000 times quicker.

Mr. Manning demonstrated this fact by allowing the photo-electric eye to look at, first, an ordinary direct-current lamp and then at a 60-cycle alternating current. The remarkable ability of the photo-electric eye to "see" such rapid changes was made clearly evident to the audience.

Mr. Hawkins also called attention to the Thyratron, a tube containing low-pressure gas or vapor. Such a tube can be employed with low voltages and is adapted for many kinds of control applications. As a relay it has a number of great advantages; it is instantaneous in action, requires a very small amount of energy to control it, and, in turn, can control a very large amount of energy. Mr. Manning demonstrated this by lighting a match and, by the tiny bit of energy released, controlled an output of 10,000 watts.

Frozen Light Demonstrated

There was also a demonstration of frozen light. Mr. Hawkins recalled that Baron Munchausen, the celebrated student of the impossible, went so far north that the ringing tone of a bell was frozen. Munchausen, so the story goes, brought back the frozen sound and thawed it out. Thursday night Munchausen was out-Munchausened by Hawkins and Manning, for they

brought some light from Schenectady, N. Y., and thawed it out until it was seen by the audience.

Plates exposed to cathode rays in the Schenectady laboratory became brightly fluorescent, that is, capable of giving off light, and in this condition were plunged into liquid air at a temperature hundreds of degrees below zero. The light was practically "frozen," and when the plates were thawed out in Detroit at the Dinner, the plates began to glow with a display of yellow, purple and red light.

PAST-PRESIDENTS AND NEW PRESIDENT OF THE SOCIETY IN ATTENDANCE AT THE ANNUAL MEETING

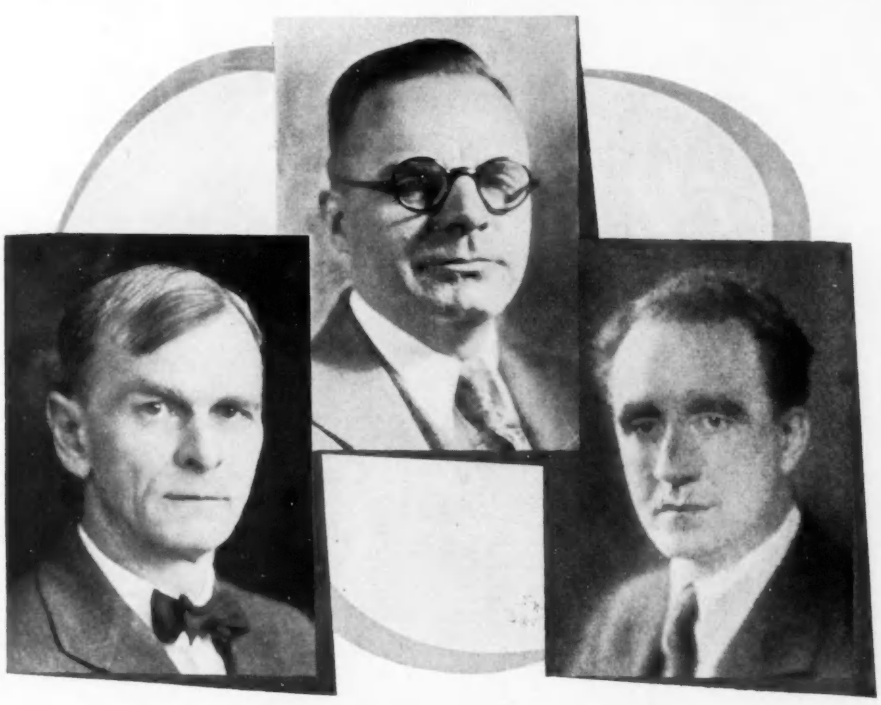
(Left to Right, Standing) B. B. Bachman, J. C. Vincent, T. J. Lítle, H. W. Alden, J. H. Hunt, W. R. Strickland

(Seated) W. G. Wall, Vincent Bendix, H. M. Leland, Edward P. Warner, David Beecroft

Mayor Murphy Makes Scholarly Address

Contrary to the usual custom of mayors, Mayor Murphy, of Detroit, not satisfied to make the usual brief address of welcome, delivered a scholarly address on the fundamentals of changing conditions, pointing out that education has mightily changed in the last five decades. Education, he declared, formerly belonged to the restricted class, in the main to the well-to-do and those of leisurely habits. It was confined largely to the letters, religion, philosophies and professions. All this has been changed because something has happened in our Country. One explanation of the change, in his opinion, is that this is an industrial age; the age of automatic machinery; and of special work; and special knowledge, technical knowledge, must be coupled with fine cultural training.

Mayor Murphy traced the progress of the last 50 years, pointing out that all the far places of the earth have been reached by our intrepid adventurers and scientists and, through the automobile and our awakened thinking, the world has been brought closer together. The social and economic conditions have been radically altered. He pointed out further that not only has this had its effect in the business world but that the normal expectancy of life has been extended by 20 years. Politically and geographically, the world is new.



TOASTMASTER AND SPEAKERS AT THE DINNER

L. A. Hawkins (Left), of the General Electric Co. Laboratories, Who Explained the Mysteries of the Atoms; P. J. Kent (Center), Toastmaster and Chairman of the Detroit Section; Mayor Frank Murphy, of Detroit (Right), Who Welcomed the Visitors and Gave a Sociological Address

The Mayor eulogized Detroit, pointing out that it has doubled its population by decades, and that a group of young men in overalls—bicycle riders, car checkers, engine wipers, and the like, few with any education beyond the grade school—had seized an industry and made it the greatest one in the world today.

Toastmaster Introduces Guests

P. J. Kent was Toastmaster, and James Schermerhorn, Jr., was Master of Ceremonies. After introducing the several guests at the table, including a number of Past-Presidents of the Society, Mr. Kent called upon Vincent Bendix, the new President, who, in a few modest remarks, thanked the members for their loyalty and confidence and stated that he hoped that his incumbency of this high office would be accompanied by prosperity and progress.

Among those at the speakers' table were:

Mayor Frank Murphy

P. J. Kent	W. Cameron
Vincent Bendix	George L. McCain
O. T. Kreusser	B. B. Bachman
E. L. Manning	David Beecroft
T. J. Lítle	H. M. Leland
J. H. Hunt	H. W. Alden
W. G. Wall	C. B. Veal
W. R. Strickland	Norman Shidle
E. P. Warner	L. A. Hawkins.

Business and Body Session

New Officers Announced and Committee Reports Presented—Towle Talks on Body Principles

AT THE ANNUAL Business Meeting on Monday night, President Warner disposed of the business before the meeting in the short space of less than quarter of an hour. He referred to reports of the Meetings, Membership, Publication, Research and Sections Committees as printed and distributed at the session and as published in this issue of the S.A.E. JOURNAL. Reading of the reports was dispensed with and, on a motion made and carried, they were approved.

Chairman Boor moved that the reports of the Divisions of the Standards Committee, as printed and distributed and with certain amendments made by the Council at its noon meeting, be approved. The motion was carried. Details of the changes and action taken by the Standards Committee and Council are given in another section of the news report of the Annual Meeting.

Officers Elected for 1931

President Warner then announced the report of the tellers on the election of officers of the Society for 1931 as given on printed slips distributed at the Annual Dinner in New York City on Jan. 8. The new officers are as follows:

President: Vincent Bendix

Vice-Presidents:

George W. Lewis, representing Aircraft Engineering

Arthur Nutt, representing Aircraft-Engine Engineering

W. F. Joachim, representing Diesel-Engine Engineering

L. R. Buckendale, representing Motor-Truck and Motorcoach Engineering.

E. S. Marks, representing Passenger-Car Engineering

C. B. Parsons, representing Passenger-Car-Body Engineering

A. K. Brumbaugh, representing Production Engineering

F. K. Glynn, representing Transportation and Maintenance Engineering.

Members of the Council: F. S. Duesenberg, Norman G. Shidle and C. E. Tilston.

Treasurer: C. W. Spicer.

The foregoing officers-elect will, with the following, constitute the Council for 1931: Edward P. Warner and W. R. Strickland, Past-Presidents; Ralph R. Teetor, F. K. Glynn and A. W. S. Herrington, Councilors elected last year to serve two years.

A call was then made for nominations of members-at-large to serve on the Nominating Committee for the nomination of officers to serve in 1932. The following were nominated: D. Beecroft (Metropolitan), George McCain (Detroit), Oliver Clark (Detroit), Chris Bockius (Detroit), Harold Nutt (Chicago) and F. C. Chandler (Chicago). The nominees were voted upon by the raising of hands, and Messrs. Beecroft, McCain and Nutt were declared elected.

Body Activity Nominating Committee Elected

This concluded the work of the Business Meeting, and President Warner relinquished the chair to L. Clayton Hill as Chairman of the Body Session. This session was opened by a business meeting of the Body Activity to elect a Nominating Committee of the Activity, as provided in Section B26 of the Constitution, for the nomination of a Vice-President of the Activity. The following nominations to the Nominating Committee were made from the floor: William N. Davis (Detroit), C. B. Parsons (Detroit), A. J. Neerken (Detroit), Oliver Clark (Detroit) and Hermann Brunn (Buffalo). Alternates nominated were James Levy (Detroit) and Hermann Brun (Buffalo), as only four nominations were in order for nominees. The nominations were declared closed and the nominees elected.

All business having thus been quickly dispatched, Chairman Hill introduced H. Ledyard Towle as the speaker of the evening, who he said would talk on design and color as factors in marketing modern motor-cars. He referred to the work of Captain Towle as a machine-gunner and in the Camouflage Corps in the American Army during the World War, and remarked that after serving as art director for the General Motors Corp. he is now engaged in the same capacity with the Campbell-Ewald Co.

Basic Principles of Design

Mr. Towle gave a very delightful informal 45-min. talk on the subject of car design in which he dealt about as much with chassis as with body design, because he said that the chassis and the body are one. He roamed over a wide field in drawing illustrations of

PROMINENT PARTICIPANTS IN THE BODY SESSION

L. Clayton Hill (Top Left), Chairman; H. Ledyard Towle (Top Right), Who Gave an Absorbingly Interesting Talk on Design and Colors

(Bottom, Left to Right) Arthur Nutt, of Durant Motors Co.; Herbert Chase, of *American Machinist* and *Product Engineering;* and H. T. Woolson, of the Chrysler Corp., Discussers

principles to be followed in design and also in color treatment, saying that there are certain basic principles of elementary design which it is interesting to consider. He called the age in which we are living "The American Renaissance." The burden of his comments was that, if a structure or an article is designed and built so as properly to perform a specific function, it is inherently beautiful and needs no embellishment.

If we go back to nature for basic principles, we are pretty safe, asserted Mr. Towle, and he likened the Arabian stallion and the greyhound to automobile roadsters and racing cars. He also spoke of the change in woman's fashions from the days when the figure was distorted by leg-of-mutton sleeves, bustles and enormous hats to the present style of figure-fitting dresses. He pointed out that in all four-footed animals the motive power is in the rear legs, and ventured the prediction that the powerplant in automobiles will some day be in the rear.

The speaker made a plea for some individuality and personality in automobiles, and commented on the fact that at the automobile shows this winter the cars in general look a great deal alike, which fact he attributed to fear of spending money on something that the public may not like. However, he said that the public would take whatever is offered it if an explanation is made of why it is designed in a certain way. As an illustration of personality, he pointed to the railroads which have given an imaginative appeal to their fast through trains by giving them individual names, such as the Twentieth Century, The Chief, and, in France, the Golden Arrow and Blue Arrow.

Cars To Be Like Tear Drops

The automobile of today is a refinement of the buggy, said Mr. Towle, who remarked that the most advanced body and chassis designers in this Country and abroad think that the teardrop design will be the design of the future, with the big end in front, which is the perfect aerodynamic design, as evidenced by the wings of the airplane. The new German motorship Bremen, which holds the Atlantic speed record, has her blunt end at the front under the water line and falls away to the stern; in other words, she is back frontwards, as that has been found to give least resistance.

Road Speeds To Become Higher

The speaker predicted that the average automobile road-speed of 45 to 50 m.p.h. of the present day will be increased to 65, 75 or more miles per hour on the super-highways that are being constructed. Then it will become necessary to work the funny big lamps that are now out in front into the body lines and to get rid of numerous other protruding parts that slow up the car.

Not much that is new in the way of material or upholstery is evident in new cars, and the speaker recommended that body men go outside of their own industry and see what is being done in the furniture marts in Chicago and New York City. He also spoke of the desirability of providing for the heating of bodies and of ventilating them without the necessity of opening windows. He made the rather surprising remark that color does not exist and invited the audience to inspect the large framed chart displayed on the easel, which showed the color spectrum as a very short section of a range of waves extending from the very long radio waves at the left end of the scale to the extraordinarily short waves of the cosmic rays recently discovered by the physicist, Millikan. All of these, he said, are the same basic waves but of different lengths. (See p. 263.)

As for colors to be used on automobiles, Mr. Towle recommended following the preference of the public as ascertained by dealers all over the Country, and said that dark blue and maroon were most favored by a large number of boys from all parts of the Country. However, he advised "changing the road picture" by using brighter colors on certain models.

Streamlining Becoming Necessary

Lively discussion followed the conclusion of Mr. Towle's talk and centered largely around the question of road speed of the future and the streamlining of cars to reduce wind resistance. Among the active participants were Chairman Hill, Mr. Towle, David Beecroft, Mr. Edling, of the Fisher Body Co.; Harold Nutt, of the Durant Motor Co.; Mr. Betancourt, of the Hudson Motor Car Co.; Joseph Anglada, of the Anglada Motor Corp.; Herbert Chase, of the McGraw-Hill Publishing Co.; and H. T. Woolson, of the Chrysler Corp.

The prevailing theme was that, in the near future, speeds on the super-highways will go up to 60 to 75 m.p.h. and that streamlining will become necessary and will win public favor. Mr. Edling voiced the opinion that two types of car will be needed in the future, one of short length for low speed in cities and the other of long streamlined design for the open road, but that excessive speed is dangerous. Chairman Hill and others maintained that speed, *per se*, is not dangerous, and that statistics show that most accidents occur at slow speed.

Mr. Hill referred to wind-tunnel tests made in Detroit under the supervision of Professor Altman, of the University of Detroit, and expressed the belief that automobile bodies of the future will have the bulky part forward. There was considerable discussion in this connection regarding the desirability of placing the powerplant at the rear, where it was in the early days of the industry.

Fuel Research Holds Attention

Bureau of Standards Papers on Gum and Fuel-Line Temperatures Impress a Large Group

CLOSE attention was given by a large roomful of automotive engineers and oil men to the two papers on the program for the second morning session. This was devoted to fuel-research subjects, and J. B. Macauley, experimental engineer of the Chrysler Corp., occupied the chair. The first paper was on A Comparison of Methods for Determining Gum Contents in Gasolines, and was written by Dr. O. C. Bridgeman and Elizabeth W. Aldrich. The second was on A Survey of Current Automobile and Bus Fuel-Line Temperatures, and was written by Dr. Bridgeman and Hobart S. White.

A rather unusual feature for an S.A.E. meeting was that the first paper was read by Miss Aldrich, and her clear, distinct and expeditious presentation of it was well received by the audience, which rarely has the pleasure of having a woman present a paper on such a technical subject. Dr. Bridgeman presented the second paper without reading it, giving instead a short introductory explanation of the research into the subject of vapor lock and then summarizing the Bureau of Standards investigation of fuel-line temperatures and their significance as slides were thrown on the screen.

Three pieces of written discussion on the papers were presented but there was little impromptu oral discussion. All of the discussion came from oil company representatives and investigators of fuel problems. Seemingly the car engineers came to listen instead of to talk, and they no doubt carried away some valuable information that can be applied very promptly to cars and motorcoaches with beneficial results.

The paper on fuel-line temperatures appears in full in this issue of the S.A.E. JOURNAL and the discussion on it will be printed in an early subsequent issue. The one on gum-testing

methods is scheduled to appear shortly, together with the discussion on it.

Gum-Testing Methods Compared

In opening the session, Chairman Macauley remarked that engineers had for a long time been disinterested in the fuel that it was necessary for their engines to use but that a marked change had occurred in the last three years because of the changes that have been made in the fuels developed. As for methods of testing gasolines for their gum contents, he said that he recalled one case in which five samples of identical fuels were submitted to as many leading laboratories in this Country for determination of the gum content and the results of these determinations varied as much as 100 per cent.

The Bureau of Standards paper, as presented by Miss Aldrich, reviewed an investigation of the copper-dish, the glass-dish and the air-jet method and gave the results in tabular and graphical forms. Twenty gasolines and as many blends of them with a gum-free gasoline were tested, and the data obtained showed a much larger residue of gum obtained by the copper-dish method than by the others and the least residue obtained by the air-jet method. Factors that were varied in the tests to ascertain their effects were (*a*) time of evaporation, (*b*) temperature and (*c*) the atmosphere surrounding the gasoline during evaporation. For the last, the samples were evaporated from flasks at reduced pressure in atmospheres of carbon dioxide and of nitrogen and the results compared with data obtained by the air-jet method.

Summing up the work, the authors state that it has shown that reproducible methods are available but that there is insufficient evidence to show that any of them is significant as regards gum deposition in the engine. A logical mode of attack on the problem is the development of a method for the determination of true gum-content, the correlation of data obtained by this method with results by a laboratory flow-method simulating manifold conditions and verification of this correlation by means of engine tests.

Two Better Test Methods

J. C. Molitor, junior chemist of the Vacuum Oil Co., presented written discussion pointing out that the Bureau of Standards had not given any comparative data obtained by the steam-oven method, and he gave tabulated results secured by the Vacuum Oil Co. with a modified steam-oven method and the air-jet method on 40 gasolines of various gum contents. Three facts that are apparent from these data are that the results by the steam-oven method are much lower than those by the air-jet method, that there does not appear to be any definite relation between the results by the two methods, and that each method is satisfactorily reproducible, with a slight advantage to be credited to the steam-oven method.

Dr. A. E. Becker, of the Standard Oil Development Co., remarked that the gum problem had been well stated on the first page of the Bridgeman and Aldrich paper. The car user is interested in the gum content of the gasoline at the time it enters the carbureter and, in some cases, also at the time it enters his storage tank. That means that we must first develop a reproducible test that can be used by everybody and that will show the actual

THOSE TAKING PRINCIPAL PARTS IN THE FUEL-RESEARCH SESSION

(Top, Left to Right) J. B. Macauley, of the Chrysler Corp., Chairman; Dr. O. C. Bridgeman, of the Bureau of Standards, Co-Author of the Two Papers Presented; Miss Elizabeth W. Aldrich, Who Presented the Paper on Test Methods for Gum Contents; Hobart S. White, Co-Author of Paper on Fuel-Line Temperature, Presented by Dr. Bridgeman

(Bottom) Prof. George G. Brown, of the University of Michigan; J. C. Molitor and F. C. Burk, of the Vacuum Oil Co., Who Presented Written Discussion; Dr. A. E. Becker, of the Standard Oil Development Co., an Oral Discusser

gum-content of the gasoline at the time of test. One of the factors involved is time of evaporation. Dr. Fisher, one of the authors of a paper cited by Dr. Bridgeman and Miss Aldrich, has, he said, modified the air-jet method so that the time of evaporation is practically eliminated. This consists in dropping the gasoline sample drop by drop into the dish and at the same time blowing the current of air onto the gasoline. Thus there never are more than two or three drops in the dish.

R. E. Wilson, of the Standard Oil Co. of Indiana, expressed regret for the amount of time wasted in studying gum content by the copper-dish method and also that the steam-oven method had been omitted from the Bureau of Standards study. His experience has been that the latter method is satisfactory, possibly with some modifications. The Fisher modified air-jet method mentioned by Dr. Becker is essentially flash distillation simulating manifold distillation, and the few experiments made by the Indiana organization in that type of distillation parallel quite closely the results obtained by the steam-oven method.

Fuel-Line Temperatures Discussed

Following Dr. Bridgeman's presentation of the paper on fuel-line temperatures, Chairman Macauley remarked that the survey should bring home very clearly the picture that faces the motor-car and motorcoach designer in handling, with present fuel systems, the fuels now available in the market. The replacement of the vacuum tank by the engine-driven fuel-pump has, he believes, been a good move, but it unquestionably has introduced complications into the problem of vapor-locking because, if fuel contains vapor, the pump does not supply enough fuel to the engine, and also because the pump is installed on a hot crankcase.

Refiners stand ready, said Mr. Macauley, to furnish gasolines that are better than those used in the past or that are being supplied at present, provided the fuel systems are able to handle them. Failure of the car designers to permit the refiners to supply this more volatile fuel means a certain economic loss not only to the refiners but to everybody involved. However, there are certain limitations beyond which the motor-car designer can hardly be expected to go. One of the limiting factors is the temperature of the air passing through the radiator core, as the temperature of the pump will be somewhere between that and the temperature of the jacket water in the cylinders. A point that was not much stressed in Dr. Bridgeman's paper, but that is of importance, he said, is the idling temperature, which may interfere not only with the idling of the engine after a hard run but with the fuel supply to the engine after starting again so that maximum speed cannot be attained.

Prepared discussion was presented by F. C. Burk, junior automotive engineer of the Vacuum Oil Co., who gave data on tests made on gravity, fuel-pump and vacuum-tank systems to determine vapor-locking temperatures. The data were compared with predicted vapor-locking temperatures based on the Reid vapor-pressure. The highest observed vapor-locking temperatures was 48 deg. fahr. above atmospheric to assure freedom from vapor lock while running at summer temperatures. In more than the average number of cars a vapor pressure not higher than 6.5 lb. per sq. in. is required of the refiner. More extensive use of stabilizing equipment by all oil companies will therefore be necessary so that they can lower the vapor pressure of the gasoline as well as removing excessive quantities of propane. The latest models of some of the car manufacturers indicate, said Mr. Burk, that the automobile engineer is striving to lower the fuel-system temperatures so as to prevent vapor lock.

Maximum and Atmospheric Temperature Relation

Prof. George G. Brown, of the University of Michigan, also presented prepared discussion, in which he stated that work done for the Natural Gasoline Association of America had given results very similar to those reported by Dr. Bridgeman. He said that it is found that the maximum fuel temperature under the majority of driving conditions would not exceed one-half the atmospheric temperature plus 100 deg. fahr. This method of expressing temperature is perhaps more satisfactory than simply determining the difference between the fuel temperature and the atmospheric temperature, as modern cars are equipped with thermostatically controlled radiator shutters and the temperatures under the hood are more nearly constant than the atmospheric temperature, so that the difference between the maximum fuel temperature and that of the atmosphere may be considerably greater in cold weather when the shutters are closed than in warm weather when they are open. In conclusion, Professor Brown said it is particularly important that designers modify or improve their fuel systems so that they will operate satisfactorily with the more volatile fuels, as the easier starting and freedom from use of the choke obtained with such fuels will cause the public to continue to demand and service stations to supply volatile fuels which may vapor lock on cars not designed to limit the maximum temperature of the liquid fuel. Professor Brown's personal opinion is that the maximum fuel temperature should not exceed one-half the atmospheric temperature plus 80 deg. even under idling conditions on cars equipped with radiator shutters.

Live Production-Session Topics

Machine-Tool Obsolescence and Practical Drilling of Cast Iron and Steel Studied

ALTHOUGH widely different in subject matter, the two papers presented at the Production Session held Tuesday evening, Jan. 20, increased the store of data already available and thus contributed greatly toward furthering the progress of truly scientific production-methods. Machine - Tool Obsolescence was the title chosen by L. A. Blackburn, J. W. Brussel and A. R. Fors for their paper. The second paper was entitled Torque, Thrust and Power for Drilling, the authors being O. W. Boston and C. J. Oxford. Under the able chairmanship of E. F. DuBrul, general manager of the National Machine Tool Builders' Association, Cleveland, constructive discussion followed the presentation of each paper; in addition, a business session of the Production Activity was held.

Controlling Obsolescence-Factors Cited

Obsolescence relates to a fact that is concerned only with the economic value of an article and not its physical condition, according to Mr. Blackburn and his collaborators, who pointed out how this definition rather than that given in the dictionary applies to machine-tools. Formerly, the factor of machine-tool depreciation was equal to, or greater than, obsolescence; but now, the tables have been turned. Factors that render machine-tool equipment obsolete, such as accounting policy, stability of product, growth of the organization and designing flexible single-purpose machines, were listed and discussed briefly.

Several formulas for determining the savings to be expected from new equipment were presented, and the reasons why accurate predictions can or cannot be based upon them were stated. The authors expressed the hope that a bomb-proof formula which the majority of executives will accept as being accurate will ultimately be developed.

In the discussion prepared by Charles B. Oesterlein, he stated in part that Mr. Blackburn and his collaborators had defined obsolescence as relating principally to the economic value of an article without any regard to its physi-

cal condition. If this interpretation is accepted, he said, then a most important detail to be given consideration is to find proper means of measuring true economic value. This requires determination upon a measure or formula for the purpose and, when such a formula has been developed, the results through its use can be no more accurate than is the formula itself.

In Mr. Oesterlein's opinion, the solution of this problem begins with the adoption of the recommendation of the authors with reference to computing costs. Then the accounting procedure should be revised to base averages on accurate standard costs instead of upon averaged actual costs. This would not only consign wastes to a "manager's controllable" account, removing them from factory costs, as was pointed out in the paper, but in addition costs would be shown as they can be and should be shown with all wastes eliminated. Correct costs alone will almost automatically earmark obsolete equipment. This would make each piece of equipment stand on its own feet in place of concealing facts in regard to operating costs by the application of an average burden rate. Comparison can then be made with modern equipment on the same basis.

Policy of Accounting Important

In his prepared discussion Chairman DuBrul laid emphasis upon the fact that the authors of the paper had done well to stress the importance of the policy of accounting. He mentioned the cost-accounting department of the National Machine-Tool Builders' Association, and said that all of the problems mentioned in the paper are encountered by the Association. He deplored the tendency to be guided by "averages," and agreed with the authors that a safe formula would be to buy new machinery only when it costs more not to buy it, and then set about to prove it. But to get the proof accepted means that the premises of one's reasoning must be accepted by those to whom it is presented. He remarked that many people start arguments from entirely different premises, and that therefore they are not talking about the same thing at all. Cooperation between the Engineering Societies and the Equipment Managers' Associations would do much to make the use of equipment formulas more than being merely a piece of mental gymnastics which managers now think are entirely unnecessary. He advocated cooperation with regard to the development of a formula, and, having worked out a rational, defensible, practicable formula, he urged that management be made to realize and understand how the use of this formula will protect profits.

Some other points of Chairman DuBrul's comments included a remark that, although a man can tour his plant and see various individual operations therein, there is no place in that plant where he can stand and view everything that is going on in the plant simultaneously. Shop men are entirely too prone to neglect the importance of cost figures, because they believe that figures have no life in them. These men must be convinced that if the figures are compiled properly by the accounting department, the manager can sit at his desk, read the statistics and comprehend everything that is being done in the plant.

Production Figures Should Be Guaranteed

F. B. Heitkamp said that, to make production figures interesting, they should be guaranteed. He represented R. W. Harrison, of the Cincinnati Milling Machine Co. He stated that his company has made a great many production estimates that were conservative to the extent of 15 per cent during the last two years, and that reputable manufacturers do the best they can to provide the best production, with the best materials that are available. He made a plea to the automobile industry for stabilization of buying, and showed two curves: One curve was the order curve *of* the machine-tool industry; the other was the order curve *to* the machine-tool industry. They were compiled from data obtained from a group of typical machine-tool companies. He suggested that more of these production formulas be applied to some of the obsolete tools that are now in use in shops, so that tool builders can replace those tools in a slack period, or an easier period, and be ready to furnish high-production tools when the demand for them is made. In conclusion he said that there is a necessity for the automotive manufacturers to give facts so that the machine-tool manufacturers can design to provide a net return on investments.

Drilling Cast Iron and Steel

Professor Boston stated that tests were conducted on drilling various grades of steel and cast iron in a specially equipped drill-press at the University of Michigan, and were reported in detail in a previous paper. The present paper is an extension of the results of these tests in formulas, tables and charts for determining the thrust, torque and horsepower that will be required in practice for drilling with drills of 1½-in. or smaller diameter in the various materials that were tested, which were representative of those commonly used in industry.

Production-Activity Business-Session

This Session was convened as a regular Business Session of the Production Activity for the purpose of electing a Nominating Committee and two Alternates to select a consenting nominee for Vice-President of the Production Activity of the Society and

CHAIRMEN, SPEAKERS AND DISCUSSERS AT THE PRODUCTION SESSION

(Top) A. R. Fors, of the Continental Motors Corp., and J. W. Bussel, of the Timken-Detroit Axle Co., Collaborators on Paper on Machine-Tool Obsolescence with L. A. Blackburn (Right), of Detroit

(Bottom) E. F. DuBrul, General Manager of the National Machine Tool Builders Association, Chairman; O. W. Boston, of the University of Michigan, Who Presented a Paper on Drilling Cast Iron and Steel; W. E. Smith, of the Wesson Sales Co., and E. J. Bryant, of the Greenfield Tap & Die Corp., Discussers

Chairman of the Production Activity Committee for 1932. In the absence of Vice-President John Younger, Vice-Chairman J. W. Brussel of the Production Activity Committee presided.

On motions duly seconded, the following men were nominated and elected members of the Production Activity Nominating Committee:

A. K. Brumbaugh
V. P. Rumely
John Younger
Fred H. Colvin

Also on motions duly seconded, the following were duly elected as Alternates:

A. R. Fors
L. L. Roberts

The Business Session thereupon adjourned.

Future Transportation Trends

Transportation Session Considers Operators' Probable Needs and Vehicle Improvement

THE TWO papers chosen for presentation at the Transportation Session held on Wednesday morning, Jan. 21, dealt with the future. D. W. Russell, of the Southwestern Transportation Co., presented the subject of the Future Requirements of Motorcoach Operators. John B. Walker, of the Greyhound Lines, discoursed on the Requirements for Future Motorcoaches. Under the chairmanship of Walter Tufts, this Session was provocative of a considerable amount of worthwhile discussion which was beneficial to the members and guests present. A Business Session was held also.

Operators' Future Needs

Mr. Russell said in part that there are five particulars in which the motorcoach needs to be improved; design, safety, comfort, operation and maintenance. He stated that the very nature of his subject required that he should not confine himself to a discussion of improvements which are presently available, but also should stress improvements which can be attained by the solution of engineering problems which have yet to be solved. In conclusion he summarized the future of motorcoach operation as calling for a vehicle which is:

(1) Designed and constructed as an integral unit
(2) Safer because:
 (*a*) The strongest available materials are used
 (*b*) The headlights are made brighter, non-glaring and fog penetrating
 (*c*) The instrument board and road are visible at the same time
 (*d*) The brakes are both fool and accident proof
 (*e*) There is no possibility of fumes or carbon monoxide
 (*f*) The windshield is sleet proof
 (*g*) There is no possibility that the electric wiring will become short-circuited
(3) More comfortable because:
 (*a*) All jolts, jars and jams are eliminated
 (*b*) All noise is eliminated
 (*c*) The interior lighting is strengthened but individualized
(4) More economical to run because:
 (*a*) The tare weight is greatly reduced
 (*b*) Passenger space is increased
 (*c*) The power is applied directly instead of through the transmission line
 (*d*) Either the highway or rails may be used as a roadway
 (*e*) Necessity for road lubrication or servicing is reduced or eliminated
 (*f*) Tire road changes are eliminated or are vastly facilitated
(5) More economical to maintain because:
 (*a*) All parts can be quickly inspected, removed, exchanged or installed
 (*b*) The parts are standardized
 (*c*) Only materials and parts of the highest quality are used

Motorcoach Operators' Requirements

Mr. Walker remarked, in part, that the efforts of American designers to date in improving all classes of motor-transport equipment have borne good fruit. He mentioned that it was in 1914 that a certain company introduced the first motorcoach, really a modified truck; and that it is only nine years ago that so-called motorcoaches began to appear in any great number on our highways. He referred also to the makeshift contraptions which were then in use, comparing them with the present de luxe coaches of today.

After referring to the difficulties encountered during the development process, Mr. Walker elaborated the title of his paper, stating that his subject was, really, "What Effect the Requirements of the Motorcoach Operator Will Have on Future Motorcoach Construction and Performance".

Mr. Walker said that, to determine future requirements, such questions must be asked as follow:

(1) What are the present-day requirements of the motorcoach operator?

(2) How well does present-day equipment meet these requirements?

(3) What influences are at work to modify present requirements? In other words, what major improvements are indicated?

(4) What can the motorcoach operators and the manufacturers, designers and engineers do to hasten their inauguration?

Taking up the four questions already specified, the author went on to analyze them in considerable detail, mentioning present changes either in effect or projected, both in the United States and Europe, and his conclusion is that motorcoach design is showing substantial improvements in all its various phases.

Manufacturers and operators are equipped now with a much better understanding of each other's requirements, Mr. Walker continued. There is less disposition on the part of the manufacturers to produce equipment on a "take-it-or-leave-it" basis, he said. The operators are thinking of equipment purchases less and less in terms of price and more in terms of quality construction, longer life and lower maintenance expense. This open-minded attitude makes certain that the future motorcoach-development will maintain a constant rate which will result in ultimate perfection of the motorcoach.

Wood Preservative Beneficial

In the discussion, H. B. Hewitt mentioned that considerable work has been done in developing wood preservative by the manufacturers of trolley-cars. His company purchased a number of taxicabs in 1929 and treated them with a wood preservative which was recommended as having been used on trolley-cars that operated along the seacoast. In this way the life of wood in the bodies of these taxicabs was doubled. The cabs have been very carefully examined from time to time, and positive evidence of the effectiveness of this preservative was found.

Conditions in Canada and New Jersey

A. S. McArthur said in part that the future of the motorcoach is certainly assured, even in the smaller operations in Canada. The future requirements of the unit in Canada will follow the developments that are made in the United States. Some problems in Canada differ from the average problems in the United States, with regard to road conditions, climate and the like; but on the whole the requirements that are met by a coach for operation in the United States should give suitable performance in Canada.

H. C. Eddy, who is connected with the Board of Public Utility Commissioners of New Jersey, and in the Department which has control of motorcoaches, said that 4000 motorcoaches are in State operation, and more than 1400 engaged in intra-State operation. He thinks that more motorcoaches operate in and through New Jersey than is true of any other State in the Union, although this is one of the smaller States. He continued his remarks regarding Mr. Walker's paper by enumerating what the present-day requirements of the motorcoach operator are.

Other Subjects Discussed

F. F. Chandler commented at length on Mr. Walker's discussion and analysis of costs of operation. R. E. Carlson discussed Mr. Russell's statements with

ACTIVE PARTICIPANTS AT THE TRANSPORTATION SESSION

(Top) D. W. Russell, of the Smith-Western Transportation Co., and J. B. Walker, of the Greyhound Lines, Authors of Two Papers on Future Requirements of Motorcoach Operators; Warner Tufts, of the National Motor Bus Operators Association, Chairman (Bottom) F. C. Horner, of the General Motors Corp.; H. C. Eddy, of the Public Utility Commission, State of New Jersey; A. S. McArthur, of the Toronto Transportation Commission; and J. F. Winchester, of the Standard Oil Co. of New Jersey, Discussers

reference to road lighting. Chairman Tufts made remarks related to classifying the motorcoach business into two definite groups; the city operators and the intercity operators.

A. J. Scaife remarked that the growth of the motorcoach industry has been very rapid, and that it is handicapped in two ways: First, through legal restrictions; and second, pioneering. When the manufacturer has to bring out a perfect vehicle and pioneer at the same time, he said, it is a very difficult job. He thinks that we have made progress, especially in the last five years, so that some attention can now be paid to detail refinements and easier servicing.

Views of Pacific Coast Operators

E. C. Wood, of San Francisco, said that he had been instructed by the motorcoach operators on the Pacific Coast to speak for them in regard to this important subject. The operators in the four western States are looking for further refinements and improvements. They feel that the improvements they have suggested will naturally make for more economy in operation and reduce repairs, give longer life and reduce operating costs. Constant study should be carried on to obtain a better balance in the life of the various parts that go to make up a vehicle. This will no doubt be obtained through increase in the factor of safety in the parts having shorter life.

There is yet much room for improvement in the accessibility of wearing parts so that the replacements can be made in the shortest length of time, Mr. Wood continued. The nature of these improvements will no doubt be determined by the improvement of design in the casting of the brackets and supports that hold these replacement parts. They have considerable to do with the criticism of poor accessibility of these replacement parts. There seems to be a general opinion among the engineers that more development work should be assigned to the operators in the field to bring about this balance factor and increase the safety of the unit in the field of operation.

F. C. Horner complimented Mr. Walker and Mr. Russell on their very interesting and constructive papers. With reference to the necessity for carrying 25 per cent spare equipment, as mentioned by Mr. Walker, he said that this is a very important matter and a very serious problem with which the operator is confronted. He thinks that this will be remedied to a considerable degree as progress is made in perfecting motor-vehicles, including both motorcoaches and motor-trucks, to which operating fields this is a common problem. It is perhaps not so serious for the truck operator, Mr. Horner continued, because he can delay freight, except for perishable commodities; but when an operator delays passengers, the immediate unfavorable reaction is to create considerable ill will toward the operating company.

Nominating Committee Elected

At the regular business session of the Transportation and Maintenance Activity that was convened just prior to the presentation of the papers at this Transportation Session, Vice-President F. C. Horner announced the purpose of the meeting as being to elect a Nominating Committee for the nomination of Vice-President of the Society in charge of the Activity for 1932.

On motions duly seconded the following were nominated and elected members of the Transportation and Maintenance Activity Nominating Committee:

E. F. Lowe
R. H. Van Ness
E. C. Wood
R. E. Plimpton

Also on motions duly seconded, the following were elected alternates:

J. F. Winchester
F. C. Horner

The business session thereupon adjourned.

Truck Operators' Wants Debated

Bennett Paper Praised but Truck Engineers Tell Difficulties of Meeting Desires

OPERATORS' requirements of motorcoaches and motor-trucks constituted so large a subject that it extended through two sessions, motorcoach requirements being dealt with in the forenoon meeting and the truck requirements at an afternoon session. A. J. Scaife, of the White Motor Co., presided at the latter session.

Following the brief business session of the Motor-Truck and Motorcoach Activity for the election of a Nominating Committee to nominate a Vice-President of the Activity, a paper by J. C. Bennett, of the Associated Oil Co. of California, on the Motor-Truck Operators' Requirements was read in the absence of the author by Edwin C. Wood, of the Pacific Gas & Electric Co. Mr. Wood attended the Annual Meeting as the representative of the Northern California Section and with a commission from the Southern California, the Northwest and the Oregon Sections to render a report to them on the principal features of the Annual Meeting upon his return to the Pacific Coast.

The following members were nominated and declared elected to the Nominating Committee:

A. F. Masury, International Motor Co.

David Beecroft, Bendix Aviation Corp.

F. C. Horner, General Motors Corp.

B. J. Lemon, United States Rubber Co.

The Chairman cast a ballot for the four nominees. Thereupon the following were nominated for alternates:

A. K. Brumbaugh, White Motor Co.

J. A. Anglada, Anglada Motor Corp.

The Chairman also cast a ballot electing the alternates.

Want To Know What Operators Want

Preliminary to calling upon Mr. Wood to present Mr. Bennett's paper, Chairman Scaife stated that at the Transportation Meeting in Pittsburgh last October the Motor-Truck and Motorcoach Activity cooperated with the Operation and Maintenance Activity in trying to find out just what the truck operators are thinking with reference to the equipment they now operate and how it meets their requirements and what they would like to have for operation now and in the future. In the course of a survey of motorcoach requirements made about 10 years ago, said Mr. Scaife, his organization was informed that motorcoaches having a wheelbase of 198 in. could not be operated in the large eastern cities because they could not get through the streets and around the corners, and that different types of vehicle would be needed for Boston, New York City, Newark and Pittsburgh, and a still different type for California. At that time wheelbases varied from about 160 to 220 in. However, the White Company brought out a model having a wheelbase of 198 in. which met the requirements in virtually all of the cities. Today a similar difficulty arises with motor-trucks largely because of the difference in the legal requirements in the different States. Consequently a large operator of trucks in California had been asked to give his ideas on the requirements.

Before reading Mr. Bennett's paper, Mr. Wood stated that Mr. Bennett's operation comprises approximately 1000 vehicles, operating in California over a distance of about 500 miles from one end of the State to the other.

Bennett States Large Operators' Desires

Mr. Bennett listed and discussed in his paper five reasons for having much hesitancy about presenting his views upon the subject, but stated that he felt that large-scale operators encounter the same varying conditions as are met by smaller operators. If especially equipped chassis such as are needed for auxiliary power purposes are excluded, little need exists, he thinks, for demanding specially designed chassis, and he believes that the truck manufacturer is alert to adopt improvements and that the operators' fleets are an ideal proving ground. The really significant division of the field of operations is the intensity with which the equipment is used, hence the questions to be answered are those of productive

THOSE WHO TOOK PART IN THE MOTOR-TRUCK AND MOTORCOACH SESSION

(Top) A. J. Scaife, of the White Motor Co., Chairman; Edwin C. Wood, of the Pacific Gas & Electric Co., Who Read the Paper by J. C. Bennett on Operator's Future Truck Requirements; Pierre Schon, of the General Motors Truck Co., Who Discussed Legislation; H. B. Hewitt, of the Mitten Management Corp., a Discusser

(Bottom) B. B. Bachman, of the Autocar Co.; J. G. Moxey, of the Atlantic Refining Co.; A. W. Scarratt, of the International Harvester Co.; and L. R. Buckendale, of the Timken-Detroit Axle Co., Discussers

or service life, on one hand, and of obsolescence on the other hand. Finally, he holds that cost accounting should be based on ton-miles of carrying capacity rather than on loads actually carried. He did not advocate higher maximum speed, but desires greater capacity for sustained speed. He listed as much-desired improvements the interchangeability of the major units of the chassis, reduction of chassis weight and greater uniformity in the space available for body mounting or load-carrying facilities.

Through a system of replacement units the time out of service for the fleet of 760 trucks operated by his company was one day out of each 45 calendar days for each truck during the first six months of 1930, this including time required for repairs due to accidents and for repainting in addition to normal reconditioning. These figures compare with the common experience four years ago that a truck must be withdrawn from service from 30 to 45 days in a year for general reconditioning.

Difficulties of Modernizing Old Trucks

Mr. Bennett also referred to difficulties encountered in modernizing old trucks powered with four-cylinder engines and originally equipped with solid tires, and inquired if it would have been impossible for the manufacturer of the six-cylinder engine to have adopted essential dimensions for his four-cylinder engine that would have permitted this replacement with the present engine without change in the chassis. He also indicated the desirability, from the operators' standpoint, of the manufacturers now making provision for the substitution in a few years of eight-cylinder engines without chassis change.

The author referred to the attention that is being given by large-fleet operators to reduction in the weight of bodies and cited a case in his own experience of reducing this unproductive weight on trucks of 2 to 3-ton capacity by 800 to 1000 lb. The chassis weight, however, remains at a high level and the operators feel that the manufacturers should be able to contribute substantially in the matter of weight reduction. Operators are more concerned as regards frame dimensions with the length from the back of the cab to the center of the rear axle and to the rear end of the frame than they are with the wheelbase, and he believes that increments of 6 in. on smaller trucks and 12 in. on larger trucks in these dimensions will be adequate to meet the needs.

Engineers Present Their Side

Much discussion of the various points raised followed the reading of the paper, chiefly by the engineers of the truck companies. John Walker, of Mack Trucks, pointed out that if a more powerful six-cylinder engine is substituted several years later in a chassis designed for a four-cylinder engine the truck will not be a balanced unit, and that the transmission, springs, axles and other parts should be changed to sustain the greater stresses imposed by the larger power and higher speed. He believes, however, that the truck engineers should endeavor to help operators as much as possible in this direction.

A. W. Scarratt, of the International Harvester Co., expressed doubt that extensive alterations to old-type vehicles will pay in the long run and said that extensive alterations are likely to be needed at the front end of the chassis, as there is not lengthwise room to accommodate the six-cylinder engine and changes will be needed to the cooling system, fuel system, wiring and hook-up to the transmission. Regarding interchangeability of units, he said that this is highly desirable in large fleets but has not been accomplished to any considerable extent as between competitive makes of truck, and he doubts that in the case of large truck manufacturers who produce the major portion of their chassis and have their own distinctive units much can be accomplished in this direction.

Reduction of dead weight of the chassis is a logical objective, admitted Mr. Scarratt, but how to accomplish it and still satisfy the existing curse of extreme overloads is a difficult problem. The demand is to really increase the strength of all major units of the chassis to keep pace with the abusive treatment it receives rather than to take anything out of it.

PERSONAGES TAKING LEADING PART AT AIRCRAFT SESSION

Carl B. Fritsche (Upper Left), of the Aircraft Development Corp., Chairman; E. R. Armstrong, (Upper Right), Who Wrote and Presented a Paper on Seadrome-System Ocean Airways

Ralph R. Teetor (Lower Left), of the Perfect Circle Co.; and Ralph H. Upson (Lower Right), Aeronautic Engineer, Discussers

Sustained High Speed Introduces Problems

High appreciation was expressed by B. B. Bachman, of the Autocar Co., for the frank and broad way in which Mr. Bennett had handled his subject without unduly criticizing other people and in general for the attitude manifest throughout the paper. In precisely the same spirit Mr. Bachman said with regard to sustained speed that this problem introduces a whole train of conflicting requirements; it assumes a larger powerplant, which means a lower load factor on the engine, and this is a major difficulty faced today in obtaining satisfactory operating costs.

He agreed with Mr. Walker and Mr. Scarratt regarding weight reduction, pointing out that ferrous materials have a definite modulus of elasticity and that increased impact forces resulting from higher speeds have made it necessary to stiffen many portions of the vehicle, particularly the frame. Higher speeds made possible by pneumatic tires have required brakes giving higher rates of deceleration which tend to deflect the chassis. Aluminum might be used in some parts, but Mr. Bachman inquired if the operators have any definite information as to how much a 1-lb. reduction in weight is worth to them in operating costs. It is conceivable, he said, that reducing weight by the use of alternate materials will increase the cost of the vehicle disproportionately, and if the increased cost is passed on to the buyer, can he earn a return on his increased investment, and how soon?

Mr. Bachman did not agree with Mr. Bennett on the possibility of designing vehicles today that will be susceptible to adaptation as improved equipment of a future period. He would not undertake today to take steps to provide for future engine development. He did not dispute Mr. Bennett's points that speed times weight should be the basis for regulation of operation on the highways, but questioned if operators would control impact forces by the limitation of speed. Uniformity in the dimension from the back of the cab to the center line of the rear axle seems quite possible but whether the dimensions established will be equally acceptable to different industries is uncertain. If some important industries cannot accommodate their requirements to dimensions so selected, it may be necessary for truck builders to go so far as to build more than one line of chassis.

Trends Cannot Be Anticipated

L. R. Buckendale, of the Timken-Detroit Axle Co., also complimented Mr. Bennett for the openmindedness of his paper but agreed with previous speakers respecting the impossibility of designers foreseeing the trends in the industry and pointed out how changes from solid to high-pressure and balloon tires have affected frame widths and axles and brakes. Over-all truck widths are admissible today that would have been objected to some years ago when roads were narrower.

G. P. Anderson, of the Chrysler Corp., remarked that it is not possible for engineers to design and build vehicles that will operate economically for 100,000 miles of service and then be ready to drop apart like the one-horse chaise. Economy of manufacture and quantity production make it necessary to adhere to definite standards and produce a vehicle that will give efficient operation over the maximum period or mileage for which the design is contemplated. If a builder were to try to produce one line for short mileage and another for long mileage, added expense of manufacture would be introduced. He thinks that the limited-mileage operator can obtain the best economy from a type of design that will give economy over the longer period, considering that the parts which wear out are readily replaceable.

Some support was given to Mr. Bennett's plea for anticipating the requirements a few years hence by H. B. Hewitt, of the Mitten Management, of Philadelphia, who suggested that the engineers, in developing larger engines, might consider the great investments in trucks that cannot be charged off and endeavor to develop engines and parts that will fit into some of these older vehicles. He said he had in mind one engine manufacturer who developed a larger engine and by adding a few adapters made it possible for motorcoach operators to put it into their old equipment; also axle manufacturers who have made it possible to install improved differentials in their old axles.

Opposition to Legislation Needed

Pierre Schon, of the General Motors Truck Co., spoke earnestly on the importance of operators as well as the truck companies giving heed to the tendency of State legislatures to impose more stringent restrictions on the size, weight and speed of trucks. He said that the highway engineers are the ones who must be convinced of the reasonableness of the truck operators' requirements.

The last speaker, if we except the Chairman, who always has the final word, was Mr. Moxey, of the Atlantic Refining Co., who asked the designing engineers to consider the possibility of interchangeability of parts within the major units so that the units themselves can be modernized, which is vitally essential to their long life and the economic use of equipment. He also inquired where we are going to stop in the matter of increasing the size of vehicles. Operators get machined up under one set of regulations and the railroads step in and, by some twist in traffic schedules, eliminate that type of machinery from their activities so that the business reverts to the railroad. Then the truck manufacturer brings out something bigger and better and the users again push the railroads out.

As a last word, Mr. Moxey made a plea to the manufacturers and particularly to the operators for more frankness in exchanging confidential operating costs so that men will not unwittingly be drawn into undertaking a large transportation service based on an unsound set-up of costs.

Spellbinding Aircraft Session

Economics of Ocean Airways, with Special Reference to the Seadrome System, Elaborated

THE INVENTOR and designer of the seadrome, Edward R. Armstrong, analyzed the possibilities of commercial operation of transoceanic airplane-service in general and with special reference to transatlantic operation in the splendid paper which he presented at the Aircraft Session held Wednesday evening, Jan. 21. The paper is printed in this issue of the S.A.E. JOURNAL beginning on p. 151. C. B. Fritsche presided.

In his opening remarks Chairman Fritsche said in part that according to reliable statistics, 40 attempts have been made to date to fly the North Atlantic, non-stop, by airplane; but of these only 15 attempts have been successful. Many lives have been lost, he remarked, and payloads have equaled zero. Continuing, he noted that those who have specialized in airplane design report that airplanes do not increase in efficiency with size. The standard of measurement, which is the number of pounds of useful or disposable load per horsepower as used by engineers, indicates that the most efficient plane today is able to lift from the ground only 11 lb. of useful load per horsepower.

Referring to the Do-X flying boat built by Dr. Dornier in Germany, which has a lifting power of 57 tons, he said that this wonderful machine can carry only a 10-lb. useful load per horsepower according to the inventor's own figures. This indicates that, so far as efficiency is concerned, the Do-X is less efficient than is an ordinary single-engine airplane of the cabin type common in this Country and also

is less effective than the ordinary tri-motored airplane. Evidently, said Chairman Fritsche, something new must be done to span the Atlantic by air commercially.

"I have always believed and have had implicit faith that the Divine Creator did not reveal his secrets of nature to man in order that only cities located on a continent or islands near-by should be connected commercially by air-transport lines," said Chairman Fritsche. In his belief the goal is to connect the continents; consequently, any engineering study directed to the solution of this gigantic problem of bringing Europe closer to the United States, and North America closer to Asia, is worthy of support and is particularly worthy of serious consideration by those engaged in the engineering profession.

Following the more than ordinarily fine presentation of the paper by Mr. Armstrong, which was copiously illustrated by numerous lantern slides and motion pictures, numerous questions were asked by prominent members of the audience and these were answered categorically by the author. In addition a 12-ft. model of the seadrome described in the paper, constructed of pyralin, was displayed in the rear of the room and afforded the more than 175 members and guests who had been privileged to hear the paper an opportunity to visualize to a great degree the practicability of a complete plan for building floating island. That the paper was received with more than ordinary interest was attested by the fact that, for a considerable time after the session had been adjourned, Mr. Armstrong was surrounded by a large group whose members questioned him for further explanations.

Aircraft-Engine Developments

Fuel Injection with Spark Ignition Described and Ways of Increasing Thrust Horsepower Outlined

THURSDAY forenoon's session on Aircraft Engines developed as a sort of Taylor Society, as three Taylors appeared as authors of the two papers presented. Charles L. Lawrance presided as Chairman and remarked that he had worked with all three of the Taylors.

The first paper described the investigation conducted at the aeronautical-engine laboratory at the Massachusetts Institute of Technology, to determine the practical value of the use of a fuel-injection system in place of a carbureter on an Otto-cycle engine, using spark ignition. The co-authors of this paper were C. Fayette Taylor, E. S. Taylor and G. L. Williams. The actual experimental work was done by Mr. Williams, who presented the paper.

The tests were made with a single-cylinder laboratory test-engine provided with a Diesel-engine injection pump and an injection valve for injecting fuel into the inlet manifold. A valve of special design was used for tests in which fuel was injected into the cylinder. Gasoline was used in most of the investigation, but comparative tests were run using fuel oil. Series of tests were run to compare the performance of an engine with injection into the inlet pipe and with injection into the cylinder, on one hand, with the performance obtainable with a conventional carbureter. The results were presented in lantern slides and discussed by Mr. Williams.

Fuel injection gave engine performance superior to the usual type of carburetion, the available power being increased more than 10 per cent with injection into the cylinder, and substantially lower fuel consumption was obtained. The mechanical problems were found to be simpler than those of a similar system for Diesel engines. Operation on fuel oil compared very favorably with operation with gasoline at a compression ratio at which no detonation occurred with either fuel. This ratio, however, had to be quite low because of the poor antiknock characteristics of the fuel oil. Whether gasoline or fuel oil was used, the influence of injection instead of carburetion upon the highest useful compression ratio was found to be insignificant.

Discussers Regard System with Favor

The first discusser, J. L. Goldthwaite, of the Allison Engineering Co., remarked that he thought one of the greatest contributions brought out in the paper was the development of a nozzle which would spray without giving penetration and that anyone who had worked on the problem could appreciate what its solution meant. He suggested a number of items that he thought would bear investigation. L. E. Fowler, of the Fowler Engine Co., expressed the opinion that we shall all shortly realize that fuel injection is a very definite improvement over carburetion. Like the previous discusser, he commented on the difference in volumetric efficiency, and said that if the engines were designed for injection, a much larger manifold could be used that would give greater volumetric efficiency. He inquired if Mr. Williams thought injection in a multicylinder engine would give power against the loss of power that occurs through ordinary manifold distribution with the carbureter. Mr. Williams stated that it does not seem difficult to apply the system to multicylinder engines, and mentioned several pump systems that might be used to avoid distribution trouble.

With reference to a suggestion made in the paper that, with better turbulence, the engine might have continued firing on a leaner mixture, Chairman Lawrance thought that great possibilities exist in having less rather than more turbulence and locating the spark-plug so that it will be at the point of the richest part of the mixture rather than at the leanest. Because of the stratified condition of the charge, this might be a profitable line of investigation in further development of this type of engine. J. Otto Sherer, of Detroit, suggested that if the fuel were injected very close to the time of ignition, high compression-ratios might be used without chance of knocking and would give a so-called stratified charge or localized combustible mixture at the plug and a volume of lean air in the rest of the combustion chamber.

Eliminates Some Fuel-System Problems

Mr. Kemble, of the Pennington Engineering Co., remarked that the paper was a real contribution and said, with regard to stratification, that the greatest benefits would be at part-throttle condition, where the Otto-cycle engine loses efficiency very rapidly because of the lower compression. The injection system, he said, does away with our present carburetion and distribution problems and substitutes the problems that arise in Diesel-engine work, but with the greatest difficulties of the Diesel problem removed because it is not necessary to inject so rapidly against such great pressure.

C. Fayette Taylor explained that the investigation was only a preliminary one, and that most of the ideas pointing the way to further development had been thought of. For aircraft and marine engines, a simple linkage between the throttle and the fuel-pump control, with an adjustment to correspond to the mixture controls, would give better speed-load characteristics than the carbureter gives. He admitted, however, that the problem of getting the right mixture at all speeds and loads over the wide range necessary in road and rail vehicles is a large one. An advantage of the system is that injection either into the cylinder or the manifold will work with supercharging without modification, because of the high injection pressure. The system is also free from manifold explosion, and no difficulty is presented in the metering of small quantities of fuel at idling speed with the accurate pumps now available.

CHAIRMAN, AUTHORS AND CHIEF DISCUSSERS AT THE AIRCRAFT-ENGINE SESSION

(Top) Charles L. Lawrance, of the Lawrance Engineering & Research Co., Chairman; George L. Williams and C. F. Taylor, of the Massachusetts Institute of Technology, Co-Author of a Paper on Fuel Injection with Spark Ignition

(Bottom) P. B. Taylor, of the Wright Aeronautical Corp., Who Presented a Paper on Increasing Thrust Horsepower; William G. Wall, Consulting Engineer; J. W. Goldthwaite, of the Allison Engineering Co.; and Roland Chilton, of the Wright Aeronautical Corp., Discussers

Increasing Thrust Horsepower

The second paper was by Philip B. Taylor, of the Wright Aeronautical Corp., and discussed the problem of increasing the thrust horsepower from a radial air-cooled engine. It was presented by the author and was illustrated with numerous slides. He told of advances made in this direction by different means, mainly by more effective cooling through suitable finning and the use of the N.A.C.A. cowl, the Townend ring and baffles between the cylinders. He indicated his belief that cylinders will not increase in piston displacement, and that the trend will be to use a larger number of small cylinders rather than a small number of larger cylinders. The question of fuels and detonation was dealt with at length, and very interesting curves were presented to show the greater power output and the reduction in fuel consumption with the increase in iso-octane values of various fuels. Propeller efficiency and gearing were also discussed.

A number of questions were asked of Mr. Taylor in discussion by W. G. Wall, of Indianapolis, and answered by the author of the paper. Interest was shown by Neil MacCoull, of the Texas Co., and by President Edward P. Warner in curves relating to results obtained with the different fuels. Roland Chilton, of the Wright Aeronautical Corp., emphasized the importance of improving the antiknock quality of aviation fuels, saying that 50 per cent more horsepower is now available in the standard aviation engines, if the specification for standard aviation gasoline is brought up in iso-octane rating to or a little beyond the antiknock value of the present ethylized motor fuel available at all highway filling stations for automobiles.

Tire and Rim Problems Analyzed

Chassis Session Authors Present Data on Rubber Problems, Tires and the Rim Riddle

THREE papers were presented at the Chassis Session held Thursday morning, Jan. 22, under the Chairmanship of C. C. Carlton, as follows: Rubber Problems Confronting an Automotive Engineer, by R. K. Lee of the Chrysler Corp.; Tires and the Rim Riddle, by B. J. Lemon of the United States Rubber Co.; and the Development of Drop-Center Rims, by Charles Ash of the Kelsey-Hayes Wheel Corp. An audience of about 75 members and guests greeted the authors and discussed major points concerning the papers presented. Both prepared and oral discussions followed the presentation of Mr. Lee's paper; similar discussions followed after both of the other papers had been presented.

(*Continued on page* 247)

Vincent Bendix

The New President

VINCENT BENDIX, president and a director of the Bendix Aviation Corp., of Chicago, has been a Member of the Society since 1916 and is a member of the Chicago Section. He has long been a prominent inventor and manufacturer of automotive devices, notable among which are the Bendix drive for engine starters, Bendix brakes and, more recently, aviation-engine starters and generators. He is recognized by his many warm personal friends as a happy combination of inventive genius, production expert and financier. He is keen, analytical, an idealist of great foresight and, with all, a sound but unassuming business executive who allows no detail to escape his consideration and understanding in the practical consummation of great projects.

Mr. Bendix was born at Moline, Ill., and received his early schooling in Chicago. At the age of 16 he went to New York City, convinced that his forte lay in mechanical devices rather than the pursuit of law, which he had contemplated. Close specialization in automobile and engine designing gave him a foundation upon which he later built the structure of the Bendix Aviation Corp.

Completing his studies in 1907, Mr. Bendix returned to Chicago, where he became sales manager of the Holsman Automobile Co. The following year he engaged in business for himself, manufacturing the Bendix car. Those were pioneering days, when motorists had to start their cars by cranking, and Mr. Bendix, with typical foresight, recognized that a self-starter for automobiles was the outstanding need of the day. He worked long and laboriously in perfecting the one link that would make the device practical—a connecting drive between the starting motor and the flywheel of the engine.

From the day the Bendix starter-drive became a reality, the progress of the automobile industry received a great stimulus, and today more than 30,000,000 of these starter-drives are in use on motor-vehicles and airplanes.

While developing his starter device, Mr. Bendix realized that more effective stopping of automobiles was necessary and, with untiring effort, the four-wheel braking principles were introduced and popularized in this Country. Through recent acquisitions and affiliations, his company now manufactures mechanical, hydraulic, air and vacuum brakes, brake boosters and brake testers for automobiles, as well as double-disc landing-wheels and brakes for airplanes.

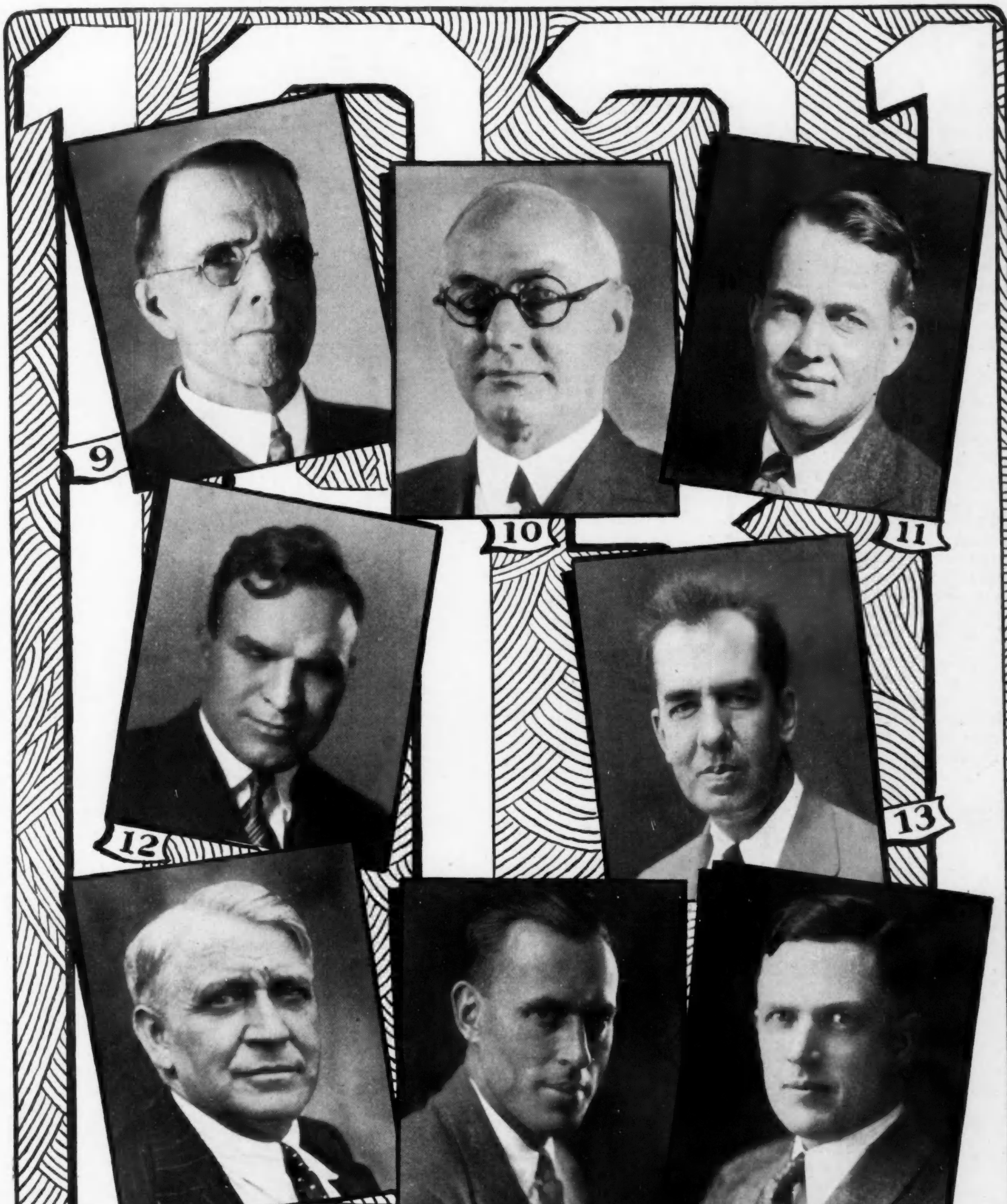
Having perfected devices for starting and stopping automobiles and airplanes, Mr. Bendix interested himself in equipment that would keep these vehicles going. His organization succeeded in acquiring the Stromberg Motor Devices Co., now named the Bendix-Stromberg Co. Subsequently other prominent automotive and aviation accessory manufacturing concerns were made a part of the parent corporation, so that today the Bendix Aviation Corp. is recognized as one of the foremost manufacturers of automotive and aviation equipment in the world, with 15 immense plants in this Country and abroad, which is evidence of the engineering genius, organizing ability and leadership qualifications of the man at the helm.

From this, it is obvious that the interests of the new President of the Society are unusually broad and that his election to the office is particularly fortuitous, as he can be expected to take a broad-gage interest in the furtherance of all of the Society's activities. Already, since his election to office, he has manifested a keen interest in and a desire to promote the work of the organization.

Vice-Presidents for 1931

(1) Dr. George W. Lewis, Representing Aircraft Engineering. (2) Arthur Nutt, Representing Aircraft-Engine Engineering. (3) W. F. Joachim, Representing Diesel-Engine Engineering. (4) L. R. Buckendale, Representing Motor-Truck and Motorcoach Engineering. (5) E. S. Marks, Representing Passenger-Car Engineering. (6) C. B. Parsons, Representing Passenger-Car-Body Engineering. (7) A. K. Brumbaugh, Representing Production Engineering. (8) F. K. Glynn, Representing Transportation and Maintenance Engineering

Councilors for 1931



(9) C. W. Spicer, Treasurer. (10) W. R. Strickland, President in 1929. (11) Edward P. Warner, President in 1930. (12) Ralph R. Teetor, (13) A. W. S. Herrington, Councilors Elected in 1930. (14) F. S. Duesenberg, (15) Norman G. Shidle and (16) C. E. Tilston, Councilors Elected in 1931 To Serve for Two Years

The Retiring President

A DEBT of gratitude is owed by the Society to its retiring President, Edward P. Warner, who has given largely and willingly of his time and effort for the furtherance of the Society's interests throughout his incumbency in office. No member has been a more ardent and energetic supporter of the Society's activities than has Mr. Warner, not only during his presidency in 1930, but for the last eight years. He was highly helpful to the staff in the New York City offices through the year 1930, during the long illness and the subsequent death last June of General Manager Clarkson, and until the filling of the vacant office by the appointment of John A. C. Warner. Throughout those nine months the retiring President was freely on call by telephone and in person for advice at his office as editor of *Aviation* in New York City.

Mr. Warner attended all of the National Meetings of the Society last year and took a very active part in them, generally welcoming the members and guests at the opening session and serving as Chairman of a session. He presented several papers at National Meetings and made addresses at a number of Section Meetings during the year. Although devoting his attention primarily to aeronautics, he has shown keen interest in all the activities of the Society, notably in standardization, on which he has sound, constructive ideas; in research, operation and maintenance, Diesel engines and Student Branch work. Besides many informal addresses made last year at meetings, Past-President Warner delivered a paper at the Detroit Aeronautic Meeting in April entitled, What Is Airplane Lightness Worth?, and one at the September meeting of the Indiana Section, entitled, The Business Depression and the Engineer.

EDWARD P. WARNER

The retiring President has been an energetic committee worker since becoming a Member of the Society, having served as Chairman of the Publication Committee for five years, as Chairman of the Aeronautic Division of the Standards Committee for four years, and as a member of the Research, Sections and Meetings Committees, and on the Riding-Qualities Subcommittee of the Research Committee and the Aircraft Division of the Standards Committee. He was Second Vice-President representing aviation engineering in 1923, a Councilor in 1925 and 1926 and President in 1930. He has also taken a lively interest in the Sections and was a member of the New England Section when he was a professor of aeronautics at the Massachusetts Institute of Technology in Cambridge, Mass., and of the Washington Section when he was Assistant Secretary of the Navy for Aeronautics in 1927 and 1928.

As an expression of appreciation, the 1930 Council, at its meeting in New York on Jan. 8, presented Mr. Warner with an electric clock.

Annual Dinner a Mirthful Affair

Coach Knute K. Rockne's Address Delights Audience of 850—Ket Runs True to Form—Schermerhorn Evokes Laughs

PRONOUNCED by many the best in years, the Annual Dinner at the Hotel Pennsylvania in New York City on the evening of Jan. 8 started the Society's new year with more than the usual zest, hilarity and a considerably larger attendance than had been anticipated. The all-star cast of entertainers drew a dinner audience of 850, and the main floor of the big ballroom was crowded to capacity, while five tables for ladies were placed in the balcony. The program was followed with extraordinary fidelity to schedule, starting and ending within a minute or two of the set time.

Members and guests began assembling in the lounge adjoining the ballroom at 6 p. m. and renewed acquaintance and conversed in pairs and groups for an hour before the bugle sounded the call to dinner. Members of the Reception Committee circulated through the gathering, greeting the arrivals cordially and making introductions.

Gets Off to a Good Start

The dinner was excellent and well and promptly served, so all were in fine humor when C. F. Kettering, master of ceremonies, sounded the gavel at 8:30 and paused a minute for quiet to start the program of addresses. Ket lost no time in getting into his well-known and vastly enjoyed vein of humorous comments. He said in part:

We have just closed a year which has meant more to the Society than any other in the last 25 years. The reason is that the industry has made one of those great cycles and landed back at practically the place from which it started; it is back today in the laps of the engineers and the salesmen. I believe I am correct in that statement because, at the National Automobile Chamber of Commerce dinner the other night, one of the features was stories 25 years old.

There is no question in my mind that the world has learned one lesson. I think it can be expressed quite simply. The one objection to engineers is that they want to change things. Sometimes they improve them so that they are not quite so good as they were before. I have been down at the Automobile Show and am impressed very deeply by the tremendous amount of work the engineers haven't done this last year. Outside of a few minor changes on radiators, which they did of their own accord, there is little new. I suggest that you take notice of the taxicabs in New York City that show how the wish can become father to the thought in these Mercedes-type racing-car cabs, which make you believe you can go faster from place to place in a taxicab than you can walk. At least there is novelty in the design.

We all know the abhorrence which production men, financiers, budget-minded experts and management have toward change. They can always write down how much a change is going to cost, but I don't believe they ever had a first-class lesson before in how much the absence of change costs. Regardless of what it costs to make a change, it costs a lot more not to make it.

Guests of Honor Introduced

Saying that "we have a very marvelous program tonight," the Master of Ceremonies took a few minutes to introduce the guests of honor at the speakers' table, as follows:

KNUTE K. ROCKNE

K. G. McKenzie, president, American Society for Testing Materials

Roy V. Wright, president, American Society of Mechanical Engineers

William B. Mayo, president, National Glider Association and chief engineer, Ford Motor Co.

A. M. Hill, president, National Motorbus Association

H. R. Sutphen, president, National Association of Engine & Boat Manufacturers

George W. Lewis, National Advisory Committee for Aeronautics

Brigadier-Gen. B. D. Foulois, U. S. A., assistant chief, Air Corps

Burton J. Lemon, Chairman, S.A.E. Sections Committee and field engineer, United States Tire Co.

Alfred Reeves, general manager, National Automobile Chamber of Commerce

H. S. Firestone, president, Firestone Tire & Rubber Co.

W. G. Wall, past-president of the Society

E. T. Satchel, president, Motor & Equipment Association

Lester D. Gardner, member of the board of directors, Aeronautical Chamber of Commerce of America

P. G. Agnew, secretary, American Standards Association

C. E. Bonnett, general manager, Tire & Rim Association, Inc.

President Warner Reviews Conditions

The next introduction was that of President Warner, who spoke in part as follows, prefacing his points with amusing illustrative stories:

There is a great wealth of uninformed talk about overproduction and technological unemployment, and, of course, all that must be the fault of the man with the technical training. There are various ways in which we can meet the situation. The easiest, or at least the most common, is to engage in the pastime, popularized in Washington a number of years ago, known as "passing the buck." But it is not enough merely to shift the blame; we have to meet the issue squarely. The trouble lies with science truly enough, but with too little science rather than too much.

It is commonplace to say that engineering is applied science, and it is no less true to say that an economic depression is misapplied engineering; misapplied largely as a result of a curious but frequently encountered delusion that design and production are in some way competitive with each other and that, if the designer could only be put under restraint and stopped from having new ideas, the production department would be able to get somewhere. Design and production are not in competition with, but are supplementary to, each other. The only guard against overproduction is a constant flow of a wealth of new products.

There is not, or should not be for us, any sharp line of division between engineering and economics, or between engineering and management. Business depressions are economic phenomena, but they offer their challenge to the engineering profession and a fresh responsibility and opportunity to its members. This means a fresh opening for useful activity by their professional organizations and that we should participate more eagerly and profitably in the cooperative activities which the S.A.E. and kindred societies have initiated and maintained.

Mr. Warner mentioned briefly as major S.A.E. occurrences in 1930 the celebration of the 25th anniversary of the Society at French Lick and "the loss of our beloved comrade, the Society's wise and shrewd and humorous and tireless guide and leader from the days of its infancy, whose memory will ever be green among us so long as any of the

C. F. Kettering

existing membership survive—Coker F. Clarkson."

He spoke of the Society's good fortune in securing John A. C. Warner as Mr. Clarkson's successor and said that, despite the business depression of the past year, the Society had increased its membership, improved its financial position and broadened its activities.

Upon motion made by David Beecroft and carried unanimously, the business meeting was declared adjourned, to reconvene at Detroit in connection with the Annual Meeting.

Kettering Introduces President Bendix

Master of Ceremonies Kettering remarked that the Warner brothers who had been in charge of the Society last year are not a subsidiary of Warner Brothers, of Hollywood, and he "was also informed that they are not brothers, and upon that I congratulated both of them." He then referred to the election of officers for 1931, as announced on slips distributed with the menus on the tables, and introduced the new President-Elect, Vincent Bendix. He said he had known this gentleman for many years in business and other associations and could speak of him only in the highest terms. "There is only one caution I want to give him for next year, and that is not to let his business get into the Society and slow it down."

President-Elect Bendix, with characteristic modesty, very briefly thanked the members of the Society for the honor they had given him and said that he was going to do the best he could this year to be of help to the Society.

James Schermerhorn, well-known newspaperman and humorist of Detroit, was then introduced and kept the gathering convulsed with laughter for the next half-hour with his witty sallies and funny anecdotes.

Introducing as the next and last speaker, Knute Rockne, and his subject, Headwork in Place of Footwork, Mr. Kettering intimated that if the Notre Dame eleven "plays football with headwork, maybe our engineering has been done the other way round." When the history of the last four or five years is written, he said, it will be stated that Knute Rockne did more for the Irish than perhaps any other man, because he introduced into the category of Irish names more new things than all the engineers of the Country have introduced into their machinery.

Rockne on Football's Educational Value

The famous coach, who is an instructor in mathematics at the great Indiana university and something of a psychologist, as his talk subsequently proved, began with laughable digs at the toastmaster, at himself, at Mr. Schermerhorn, at General Manager Warner and at "Vince" Bendix, his "assistant coach from South Bend." He had been waiting a long time, he said, to talk to engineers, because the engineering faculty had been talking to him for years, generally saying about candidates for the eleven: "He can't play, he's down in his classes." An embarrassing experience occurred about two weeks previously, when one of the players whom Rockne had carried about 20,000 miles last autumn, flunked in geography.

Becoming more serious, Coach Rockne illustrated with numerous narratives the ways in which football has educational value for college students. In a rapid-fire, inspirational half-hour address he said that he thought that football would be an adjunct to a young man's engineering training, because most teachers in engineering now are research men who look upon human beings, particularly boys, as mental automatons, and he believes that the boys can get experiences in football that will enable them to get along a little better in their human relations.

Let's Go

Four kinds of boys that are not wanted on the football teams, said Rockne, are those with swelled head and dry rot, the disorganizer who thinks that nobody is right but himself, the quitter and the mucker who hasn't enough character to show those forms of generosity known as sportsmanship. Other types weeded out are those who are failing because they make excuses to justify defeat, those who are feeling sorry for themselves, those who criticize the faults of their teammates and those suffering from an inferiority complex of which they cannot rid themselves.

James Schermerhorn

Emotion a Factor in Success

Qualities that make for success in business as well as in football are teamplay for the good of the whole organization, hope, and determination in the face of apparent defeat. These were illustrated interestingly by the recital of incidents in critical football games.

A professor of engineering said to the coach before one game, "I don't believe there is any such thing as emotion; nothing counts but cold intelligence." Rockne disagreed and let him listen to his talk to the team. Before the game with the team from Carnegie Institute of Technology he said to his team: "You are playing against a great team. I think you are just as good as they are. I think I know about what condition you are in physically and how much football you know, but one thing I don't know is what is in your hearts. The game is going to be won or lost today on what is in your hearts, and I want you to go out and show 50,000 people what is in your hearts. You men, all eleven of you, dig those cleats in deep, get your jaws set and, when you start off for that goal line—drive, drive, drive!

"That is the reason," concluded the speaker, referring to the S.A.E. sign on the wall behind him, "why I like that sign, Let's Go, because if you go, you go."

Motorboat Meeting Arouses Interest

Converted Automobile Engines and Marine Engines in Verbal Tilt —Historical Review Entertains

SUCCESS of the National Motorboat Meeting, held in cooperation with the National Association of Engine & Boat Manufacturers and the Metropolitan Section of the Society, can be measured by the fact that the room assigned to it was virtually filled with about 150 men who showed great interest by their attention, discussion and remarks after the meeting was over. H. R. Sutphen, president of the Association and vice-president of the Electric Boat Co., called the meeting to order shortly after 10 in the morning of Thursday, January 22, with remarks acknowledging the assistance of engineers in general, and in particular the help received from the development of the automobile, in producing the better marine engines and boats of today.

Two sides of one of the chief moot questions of the industry were presented in the first two papers, one by H. E. Fromm, manager of the marine-engine division of the Amplex Manufacturing Co., which is a unit of the Chrysler Corp., and the other by R. H. Garrison, of the Universal Motor Co. Mr. Fromm presented the advantages of automobile-type engines for marine service, while Mr. Garrison told why he considered strictly marine engines to be more advantageous.

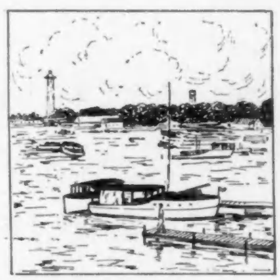
Mass production and standardization as developed in automobile - engine manufacture give great advantages to this type of engine both in cost and in accuracy, according to Mr. Fromm. Early adaptations suffered from the limitations of small crankshafts and splash lubrication, but the modern pressure-lubricated engine having large bearings is amply rugged for marine service at the speeds that are much lower than are common in automobiles.

Among the changes that Mr. Fromm made in the adaptation are the substitution of wide-face spiral gears for timing chains, providing auxiliary drive for a gear-type water-pump and furnishing a tubular-type oil-cooler. Deep or shallow oil-pans are furnished according to the angle of installation in the boat. The reverse gears are mounted directly on the engine, and a reduction gear can be mounted on the end of the reverse gear.

Ear-Marks of the Real Marine Engine

Continuous service at full load is a condition that Mr. Garrison considers more severe than that for which automobile engines are designed. Placing an engine at a considerable angle in a boat affects the water circulation in a way which must be taken into consideration to avoid steam pockets, and he observes that makeshifts result from many of the changes that must be made in carbureter mounting and manifolding.

Operation with salt water in the cooling system causes rust which the steel core-print plugs ordinarily used in automobile engines are not suited to withstand and also make it desirable to have cylinder-head-studholes and other threaded holes tapped blind, which is a procedure that is too slow and expensive for mass production. Different conditions as to moisture and temperature also make it advisable to have different fits at different points in engines of the two classes.



Accessibility in a marine engine is had under conditions that are widely different from those of an automobile engine, in which it is convenient to remove the oil-pan. Split flywheel-housings permitting the removal of the oil base without taking off the flywheel, provisions for removing the valve push-rods through the valve compartment and accessibility of the oil-pump are examples of features usually found in modern marine engines but not in converted automobile engines.

Marine engines see many more years of service than automobile engines, and marine-engine manufacturers provide service parts almost indefinitely. The shorter average life of automobiles makes service conditions in converted engines less favorable, in Mr. Garrison's opinion, after they are a few years old.

Mr. Garrison admits that some marine-engine shops lack modern facilities, but he asserts that numerous individuals with only a little garage equipment are converting car engines. Purchasers of engines from such shops run the risk of having their engines orphaned as to conversion parts.

In conclusion, Mr. Garrison asks why converters do not take advantage of the advertising of car manufacturers by calling the converted engines by their proper names.

Milestones of the Motorboat was the apt title of the historical paper by A. E. Luders, president of the Luders Marine Construction Co., who gave a racy review of the development of gasoline-propelled boats from the beginning of the present century, when the motive power invariably was a heavy-duty slow-speed engine weighing 100 lb. or more per hp. and modeled after the marine steam-engine.

The lack of safety precautions at that time was illustrated by an incident during the trial trip of a small cruiser in the course of which the owner's collie wagged his tail into a vertical drive-shaft. That was the end of that tail. That conditions have not improved too much in respect to safety is shown by an accident under similar conditions only a couple of years ago, the casualty in that case being the skirt of a petty officer's heavy coat.

Soon after the beginning of the century, newspapers and nautical magazines gave publicity to races at Monaco between light motorboats powered with automobile engines, and the Harmsworth Trophy was offered for competition at about that time. These incidents marked the birth of a sport which has grown to be an important industry.

Thundering exhausts from the Vingt-et-un, which made the breathless speed of 17 m.p.h.; the Standard; the XPDNC; the Dixie, and other creations of Smith & Mabley, Herreshoff, Crane and other designers were heard as Mr. Luders' story proceeded.

From Essington, Pa., came a bulky boat, designed by John Sheppard and powered with a pair of Chadwick automobile engines. Not for several years was its V-bottom duly credited for its achievement of 31 m.p.h. Another incident the true significance of which remained unheeded for several years was the fainting of the engineer of the Dixie II as it won a race, because of the exhaust gases discharging into the atmosphere just ahead of the crew.

The electric starter was said by Mr. Luders to be as revolutionary in effect on the marine-engine field as on the automobile. Marine engine design profited largely from developments in the automobile industry. Ability for

these developments was not lacking among the marine-engine builders, but they were hampered by small production. Developments that were particularly important in boats—such as improvements in oil filtering and cooling, manifolding and prevention of leakage of gasoline and oil—stand to the credit of the marine-engine builders.

In closing, Mr. Luders advanced the claim that no other sport or industry has reached the position enjoyed by the boat and marine-engine builders with so few casualties to mar the path of its progress.

Observations from Europe

In opening the discussion, which was deferred until all three papers had been read, Chairman Sutphen remarked that automobile builders undoubtedly are coming into marine-engine production. He told of visiting Europe last fall in company with Charles F. Kettering and George W. Codrington, president of the Winton Engine Co. While there, they visited the third motorboat show held in Paris, in a building on the banks of the Seine. Engines were shown running in a building on the dock, and demonstrations were being given on the river. Chairman Sutphen said that the industry on the whole is not as far advanced in Europe as in this Country, but Europeans are showing greater interest in reduction gearing and in Diesel engines. Many evidences of the latter interest were seen in Germany and Switzerland, including one group of eight 7000 hp. two-cycle engines weighing 10 lb. per hp., to serve as the powerplant for one boat. These engines rotate at 350 r.p.m.

A comparison of the mileage in improved highways and in waterways shows that the volume of production of motorboats will never equal that of automobiles, said Mr. Warner, of the Beaver Boat Co. One of Mr. Warner's mechanical observations was that the side clearance in gear-type water-pumps is much more important than the tooth clearance. This remark was made in connection with Mr. Fromm's claims of the durability of a gear pump having the impeller gears driven independently by lubricated gears inside the gear case.

Chain drives for marine-engine camshafts were defended by John W. Oehrli, of the Lycoming Mfg. Co. He said that converted engines are not the best, but few changes are necessary in adapting an automobile engine to marine service. Block castings he considers better than individual cylinders, and economical service is provided by removable cylinder-liners.

Differences between automobile and marine requirements mentioned by F. H. Dutcher, of Columbia University, include the greater importance of fuel economy in the marine engine, possibility of valve timing exactly suitable for the ordinary speed and the need of designing a piston to keep hot in the automobile and for adequate cooling in the marine engine. He said that the automobile type of engine may be slightly more difficult to service, but it is built so that little service will be required.

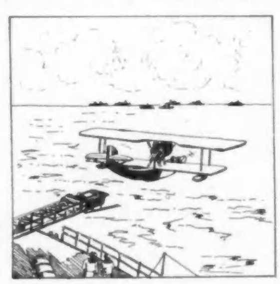
Questioned regarding the accessibility of oil strainers in converted engines, Mr. Fromm said that they cannot be removed conveniently but that the basket type of strainer does not gather foreign matter and clog because the oil is drawn up through it.

Observations of Years Are Summarized

Conclusions drawn from 25 years' experience in marine engines were summarized briefly by L. H. Grisell, of the Scripps Motor Co., as follows:

(1) Manifolds, especially on L-head engines, should be placed so that their weight tends to neutralize the torque.

(2) Cylinder-blocks should be designed so that blow-by does not strike cold surfaces where it will tend to form sludge and cause corrosion of valve-springs and sticking of valves.



(3) Life and dependability of the generator are best when it is mounted on a bracket at some distance from the engine and driven by some flexible drive like a belt.

(4) Exhaust manifolds should be located below the cylinder ports, so that condensation will not flow back onto the valves.

(5) All-aluminum pistons having thick heads are more rigid and satisfactory for large marine engines than are pistons of the Invar-strut type.

(6) The oil-pan should extend under the reverse gear, to prevent careless dumping of oil into the bilge when the reverse gear is removed.

James Craig made some additions to the reminiscences in Mr. Luders' paper and brought to mind the basic benefits of the automobile and motorboat industries in that they help the people who live in closest communities, amounting to about two-thirds of the inhabitants of the Country to reach Nature's charms quickly and easily. He also quoted H. R. Ricardo's statement that the small internal-combustion engines in the world totaled 300,000,000 hp., more than 10 times the total power of steam engines, oil engines, hydraulic plants and all other prime movers.

Chairman Sutphen called attention to the report of a committee of the National Association of Engine & Boat Manufacturers on safeguarding provisions against fire hazards and for safety in other respects, which is available at the office of the Association. Crankcase ventilation and backfire traps are covered in this report, and suggestions for further recommendations are requested.

S.A.E. Exhibit at Motorboat Show

The Motorboat Meeting was held during the Motorboat Show in a room provided by the Home-Making Center which is located in the Grand Central Palace. After the meeting a luncheon was served, and tickets to the luncheon bore coupons good for admittance to the Show.

An exhibit space in the Show was occupied by the Society, examples of the standardization work and publications of the Society being featured therein. The space was manned by Society employes during the day and by members of the Metropolitan Section each evening. Among the exhibits featuring S.A.E. standards were the following: Westinghouse electric lamps for motorboat lighting: A-C and Champion spark-plugs; Hyde propellers showing hub standards and propeller-shaft couplings; and Elco propeller-shaft ends with standard taper fitting and six-spline shaft fitting. In addition, a Chrysler Majestic engine and two Universal engines were shown, with small signs calling attention to various points where S.A.E. standards are used. Prominent in the booth was a sign presenting the program of the Motorboat Meeting of the Society, with a ribbon from Mr. Fromm's name on the program to the Chrysler engine and another from Mr. Garrison's to the Universal engine.

Miami Aeronautic Meeting

Jimmie Doolittle Was Toastmaster at Dinner of S. A. E. and Local Industrial Association

THE All-American Air Races neld this year in Miami on Jan. 8, 9 and 10 brought together not only a large number of well-known racing pilots, but also a general assemblage of the executives and engineers from the industry.

The S.A.E. dinner held on the night of Jan. 8 was a joint affair with the Greater Miami Industrial Association in conjunction with the Aeronautical Chamber of Commerce. As last year, it was held at the Columbus Hotel which was also the Air-Race headquarters.

Under the able guidance of Lieut. "Jimmie" Doolittle, the affair got under way at 7:30. The regular program was augmented by a few words of greeting from each of the guests at the speakers' table, interspersed with Doolittle's humorous remarks and introductions.

Igor Sikorsky had been announced on the program as the first speaker, but he was unable to be present for business reasons and sent Nicholas Solovioff as his representative to present the talk on Ships with Wings, which Mr. Sikorsky originally intended to deliver in person. Mr. Solovioff pointed out the great difference between the miles over water and the miles over land which must be flown if international air transportation is to become a reality. His talk centered around the valuable service of flying boats in this kind of transportation, emphasizing his remarks with figures concerning the use of boats and amphibians in present-day transportation systems, Pan-American Airways in particular. Mr. Solovioff has been associated with Mr. Sikorsky in the development of amphibians since the early conception of this type of airplane and is qualified to discuss flying ships with authority.

Speaking on Inter-American Air Trade Relations, Leighton Rogers, head of the Aeronautic Trade Division of the United States Department of Commerce, traced the history of the development of transportation and its relation to trade development and the extension of civilization from the days of the animal-drawn sled to the present means of transportation by air. In every case of the development of the new type of vehicle, according to Mr. Rogers, peoples had sought new land and new markets for their commodities. Any new form of transportation, in his opinion, must supply three fundamental needs, which are speed, the ability to open up new territory, and the ability to furnish new markets for new and old commodities and luxuries. Air transportation meets all three of these requirements.

Mr. Rogers, in commenting upon the possibilities of our trade with South America alone, quoted figures indicating the extent to which we are dependent at present upon South America for certain commodities and at the same time showing the vast percentage of our exports which go into the Latin-American countries. The value of air transportation for salesmen and executives, not only in developing our own export markets but in purchasing commodites and luxuries for import, was but one of the points touched on. The

JAMES H. DOOLITTLE

enormous savings in the transportation by air of payments for materials purchased at a distance was pointed out by Mr. Rogers, it being possible, because of the time saved and the enormous amounts involved, to show a saving of thousands of dollars in interest alone on money so expended.

Guests at the speakers' table included, in addition to the Toastmaster and scheduled speakers, Hon. David S. Ingalls. Assistant Secretary of the Navy for Aeronautics, and his aide, Lieut-Com. Moulten; Admiral William Moffett, Chief of the Bureau of Aeronautics, United States Navy, and his aide, Lieut-Com. Stanley Ring; Mayor Reeder, of the City of Miami; E. E. Aldrin, of the Standard Oil Development Co., who was also the official representative of the Aeronautical Chamber of Commerce; Sir Charles Orr, Governor of the Bahama Islands; B. B. Freeland, Dr. B. F. Ashe and Alexander Orr, three representatives of Miami civic organizations; and Walter Bruns, executive secretary of the Greater Miami Industrial Association.

The All-American Air Races were unquestionably the most successful of this series of Miami events, of which these were the third, and were exceptionally well attended. In addition to the schedule of race events, the meeting was featured by daily demonstrations of the Autogiro, piloted by James Ray, and of McDonnell's Doodlebug. Formation flying was presented daily by a squadron of Marines and also by three Navy pilots, the last two groups competing on Saturday for the Sir Charles Orr Trophy. This contest for the best formation flying was judged by Leigh Wade, one of the around-the-world flyers; David S. Ingalls, Assistant Secretary of the Navy; and Carl Egge, Secretary of the National Air Pilots Association. By a unanimous opinion of the judges, the trophy was awarded to the Marine-Corps fliers, for their very spectacular exhibition.

A very interesting new development seen at the races was the adjustable-pitch propeller, hydraulically controlled, with which the Hamilton Standard Propeller Company's Sikorsky was equipped. This was one of the experimental propellers put out by this company in its test routine, and it amply demonstrated its value.

A feature of the race events were the amphibian races from the field to Biscayne Bay and return on Saturday. The contestants were required to fly to the Bay, catch a fish, and return, the first pilot delivering a fish to the judge's stand being adjudged the winner. The following day a similar race was held, in which the pilots returned with alleged bathing beauties. Bomb-dropping contests, dead-stick landings and balloon bursting were daily events.

Noticeable improvement over previous air races in the handling of the public-address system and the supplying of information as to contestants' time, contributed much to the success of the meet.

Chronicle and Comment

Heard on Jan. 8 ACCORDING to C. F. Kettering, to make a change may be costly, yet it costs a lot more in many cases *not* to make it.

"The engineer has been in a strait-jacket for the last ten years," said Mr. Kettering at the Annual Dinner, "and I am wondering whether now, since he has had some liberties with his hands and perhaps with his head, he can take his old warped slide rule and really go out and figure something new. I am wondering whether or not his imagination has not been thwarted somewhat, but I am telling you today that an idea is worth money, and we ought to have as many ideas now as we ever had."

From Knute K. Rockne, principal speaker at the Annual Dinner, came the following observations:

"Egotism is the anaesthetic that deadens the pain of one's stupidity."

"Success is based on what the *team* does, not on how *you* look."

"Enthusiasm is the emotional urge that makes us do better than we know."

James Schermerhorn included in his humorous discussion the story of his friend who said that he was ready for any fate, because his checks had been coming back for several weeks marked "No funds" and finally he got one marked "No bank."

"A fine time was had by all" and nearly a thousand members who attended were very warm in the praises of Walter T. Fishleigh, F. K. Glynn and Burton J. Lemon, the members of the Annual Dinner Committee.

Gift for Past-President Warner ONE of the best attended and pleasantest of the 1930 Council meetings was that held in New York City on Jan. 8. In recognition of their high esteem and as a memento of a profitable year of cooperative effort, the Councilors presented to the retiring President, Edward P. Warner, a beautiful electric clock accompanied by an embellished certificate of appreciation.

Engines for Boats QUESTIONS of proper selection and installation of engines for motorboats were thoroughly aired when three excellent papers were presented to a large gathering of motorboat enthusiasts at the Annual Motorboat Meeting that was sponsored this year by the Society and its Metropolitan Section, in cooperation with the National Association of Engine & Boat Manufacturers. President H. R. Sutphen, of the Association, directed the meeting and the luncheon which followed it, as reported elsewhere in this issue.

The New Roster PREPARATIONS are almost completed for issuing the 1931 Membership Roster, which will contain the names, addresses, company connections and geographical locations of all Society members, together with a great deal of additional information regarding officers, committees and the like.

Many members have indicated their desire that a Roster be sent to them upon publication; those who have not so indicated should do so at once by writing to headquarters.

Annual Meeting Scores a Hit JUDGING from many favorable comments, the Society has never witnessed a more successful and worthwhile Annual Meeting than that which occupied the week of Jan. 19 in Detroit.

Such affairs are the result of a lot of hard work and the devotion of considerable intelligence and thought by those members of our Society who work so effectively as committee members, authors, speakers and chairmen. Sincere congratulations and appreciation are offered by the membership to those who were responsible for the success of The Big Event.

Council Selects L. Clayton Hill L. CLAYTON HILL was the unanimous choice of the Society's Council as Councilor for the current administrative year.

Mr. Hill brings to the Council a wealth of experience in Society work that was gained during his connection with the headquarters staff as Assistant General Manager and since that time. He has been active in the work of the Detroit Section and has served in numerous capacities, including that of Chairman during the past year.

Mr. Hill fills the vacancy on the Council that was left when F. K. Glynn resigned as Councilor-at-Large to accept the Vice-Presidency of the Transportation and Maintenance Activity.

Our Retiring Toilers NEW officers and committees are busily engaged in the work of the current administrative year. They will make considerable progress and will derive a large measure of benefit from this work, and a degree of compensation will come from successful promotion of the Society's interests.

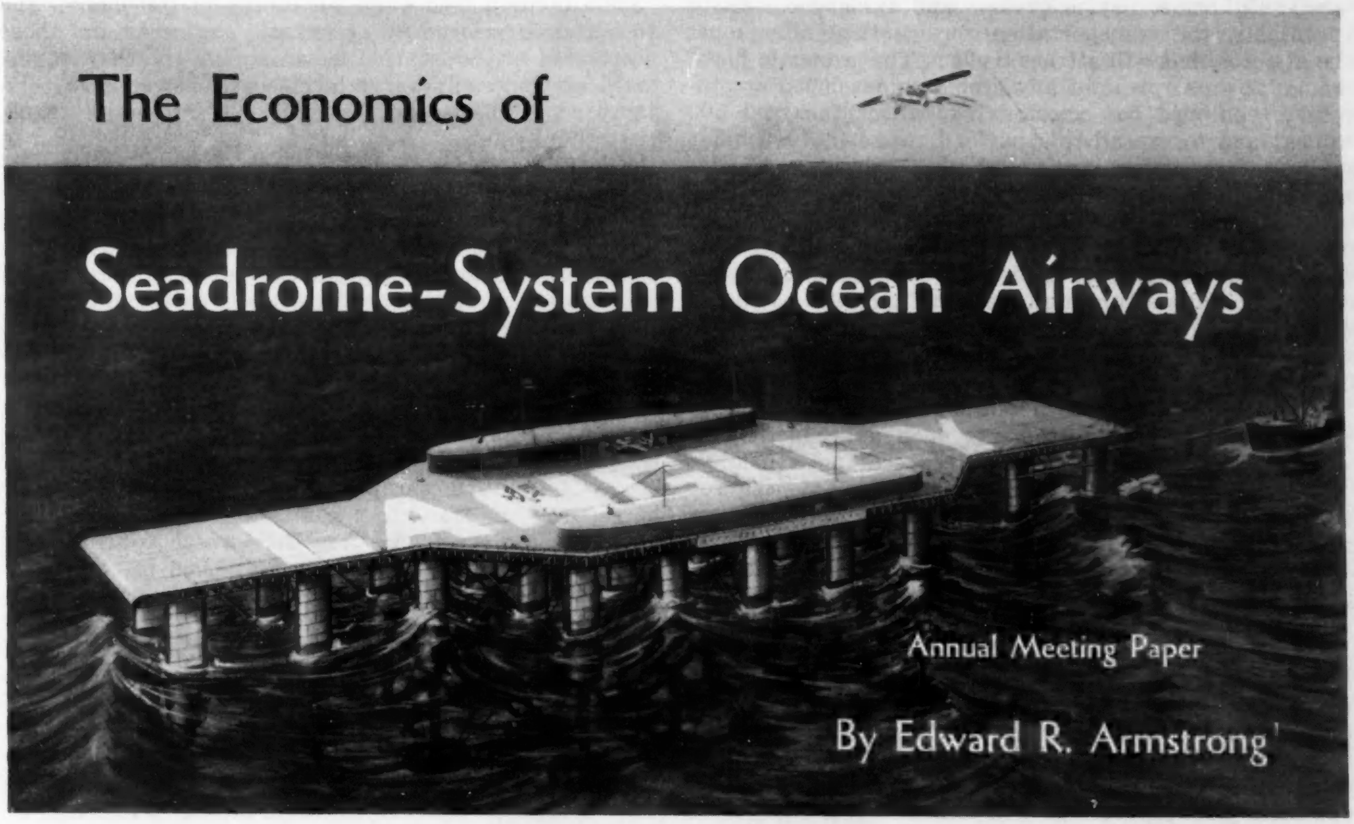
In the enthusiasm that accompanies the advancement of new plans, due recognition should be accorded to our retiring President, officers, councilors and committee men, who have been most instrumental in the establishment of new records and the attainment of important goals in the Society's history. Very few members who do not actually go through the mill can easily appreciate the vast amounts of time and energy that are given to the Society's welfare, ungrudgingly, by those who each year direct its destinies.

The Detroit Section paid a very fitting compliment to the Past-Presidents of the Society, who deserve our unfailing gratitude, by featuring them as guests of honor at the Thursday evening banquet of Annual Meeting week.

The Economics of Seadrome-System Ocean Airways

Annual Meeting Paper

By Edward R. Armstrong[1]



FROM A WORLD point of view the establishment of airways over the ocean is of more economic importance and will have a greater effect on international trade and the comity of nations than will the millions of dollars now being expended in establishing and extending continental airways. Foremost among possible ocean-airway routes, the economic need for transatlantic airplane service is becoming more imperative as the peoples of this and other countries become increasingly air-minded and recognize more and more the saving of time and money that is possible by this new means of transportation.

However, ocean flying, to be popular and useful, must be safe and profitable. Danger is inherent because of the distance that must be traveled without refueling and without engine inspection, weather reports or any of the other services that have made overland flying commonplace and reliable. That ocean airways, to be

[1] President and general manager, Armstrong Seadrome Development Co., Inc., Wilmington, Del.

Herein the inventor and designer of the seadrome analyzes the possibilities of commercial operation of transoceanic airlane service in general and with special reference to transatlantic operation. He shows the impracticability of carrying a payload on a non-stop flight of 1800 miles or more now required between land on the Great Circle route or the route from America to Europe by way of Bermuda and the Azore Islands. Continental and intercontinental airways now in operation are successful only because the flight distance, without refueling, rarely exceeds 400 miles.

Ocean flying must be safe as well as profitable. Weather conditions present the greatest hazard in aviation, whether over land or sea; and danger in long over-water flights is inherent because of the distance that must be traveled without refueling and without engine inspection, weather reports or any of the other services that make overland airplane services commonplace, reliable and safe.

Establishment of safe and profitable transatlantic airplane operation is shown to be feasible only if floating landing and service stations are provided at intervals of approximately 350 miles along the route. The seadrome was designed to serve as such a station and every detail of it has been worked out on an engineering basis with the cooperation of leading marine architects and shipbuilding, structural and aeronautic engineers. The major engineering and manufacturing companies in the United States have been associated in the development. Theoretical calculations have been supported by model and small-scale tests. The structural features are illustrated and described, and methods of fabrication, assembling, towing to location and anchoring explained.

The projected route contemplates eight such seadromes located in a direct line from a point midway between Halifax, Nova Scotia, and Bermuda, where the first seadrome will be located, and Flores Island in the Azores, thence on a line to Plymouth, England, and/or Brest, France.

Estimates of the cost of establishing and operating such a route and of revenue to be derived are given.

The author concludes his paper with an interesting discussion of the legal aspects of the project, including possible international complications, and shows that authoritative opinion holds that the seadromes will be private property subject to protection by the American Government.

successful, must pay is obvious and axiomatic. To be profitable, the transportation service they offer must be at rates that will attract traffic. The economic flight range of an airplane of any type now developed or proposed, equipped for ocean flying, will not exceed 500 miles; and to extend this payload range to 1000 miles will require almost an engineering miracle. Fundamentals of design and performance very definitely limit the economic flight-range to distances that fall far short of spanning either the Atlantic or Pacific ocean. Successful continental and intercontinental airways now in operation, ranging in length from 3000 to 10,000 miles, are possible and successful only in that their flight distance, without refueling, rarely exceeds 400 miles.

The fuel load required on long flights is an insuperable bar to payload. Improvements such as reduction in engine weight, increased power, reduced fuel consumption, more efficient propellers, and wings of less resistance will not greatly affect the economic non-stop range of airplanes or extend their possible flight distance much beyond that noted. Therefore, nothing is in sight to justify the frequently expressed opinion of both the layman and the technician that, because of improvements in airplane efficiency, we shall shortly have ocean airways connecting the continents and operating with a frequency and reliability commensurate with the land lines now being developed. Obviously, to establish a safe and economic airway operation between Europe and America, the obstacle of non-stop distance must be eliminated. Therefore the problem in establishing ocean airlines is to break the distance up into intervals commensurate with those distances found to be essential and practical for overland routes. This is the purpose for which the seadrome illustrated in the heading for this paper is designed. A series of eight of these structures, anchored to the bottom of the Atlantic, at intervals of approximately 350 miles, will remove the hazard from ocean flying and make possible a paying operation daily, at rates little if any in excess of those now charged by the high-speed steamship lines.

EDWARD R. ARMSTRONG

The seadrome is a floating landing-deck high above the waves, moored at one end so as to trail into the wind and long enough and wide enough to make possible the landing and taking off of the largest planes, the whole structure supported by a number of tubular columns of such shape and so arranged that passing waves will go through the assembly without being broken up. Buoyancy tanks are located below the columns supporting the deck truss and floor system, so as to be in the relatively undisturbed water under the waves. Still farther down, ballast tanks bring the center of gravity below the center of buoyancy and give the whole structure adequate stability. These ballast tanks are extended in circular form to act as damping discs to prevent any oscillation.

Before describing the seadrome system in detail, some of the technical and economic facts that led to the development, as being the only practical solution of the problem of ocean airways, will be given.

The opinion held quite generally by the public, and too often sponsored by aeronautic engineers and those associated with aviation development, is that super-sized airplanes, flying at terrific speed over great distances, will shortly be the vehicle of our major transportation systems. Nothing justifies this conclusion in the face of airplane-flight efficiency curves. The pounds-per-horsepower curve is possibly the simplest example and the best measure of performance, which, in the last analysis, is the basis of economic operation. Fig. 1 shows the load carried per horsepower, in terms of speed in miles per hour, for practically all representative airplanes of the present day both here and abroad. Fig. 2 gives the same information for 1920, 1925 and 1930.

In the range of practical operating speed between 100 and 200 m.p.h. little improvement has been made in the weight carried per horsepower during the last 10 years. The first airplane to cross the Atlantic, the NC4, in 1919, carried virtually the same load per horsepower as the latest contestant for transatlantic honors, the Dornier X. The NC4, with four Liberty engines totaling 1600 hp., carried 28,000 lb. while the Dornier X, with 12 engines of 7200 hp., carries something over 100,000 lb.

Proposals for transatlantic airlines, operated both with dirigibles and with airplanes, are frequently made. A wide search of the literature will fail to reveal capital-cost estimates and operating costs that will justify such ventures as business proposals. Commander Burney, of the R-100, following the recent successful crossing of the Atlantic by the British dirigible, estimated that $25,000,000 would be required to establish a bi-weekly service between America and Europe. No one, as far as I am aware, has made public even a tentative estimate of a transatlantic service by airplane.

The suggestion has frequently been made that the Atlantic route via Bermuda, the Azores, Spain and then to Europe would be feasible for an airmail service at least, which possibly could later be developed for passenger carrying. Black & Bigelow, consulting aeronautical engineers associated with the seadrome development, have made a rather complete study of seadrome ocean-airway operations and have prepared a comparative estimate from an economic point of view of a non-seadrome line over the Bermuda-Azores route. Predicating the operation on the use of flying-boat equipment that is now available or in process of building, they show that it is not technically possible to operate the Bermuda-Azores hop, exceeding 2000 miles, with any payload at all; so all such proposals must await the development of the superplanes which apparently will be possible only by some revolutionary discovery that cannot now be forecast.

Long Airplane Flights with Payload Impracticable

The following summary prepared by Black & Bigelow in connection with their investigation of a non-seadrome airway route to Europe is of special interest at this time when so much public attention is being directed to ocean airlines:

We have studied the performance characteristics

of existing flying boats and amphibians and have worked out the possible payload at varying flight-ranges. We find it impractical to achieve sustained flight over 1800 miles with payload under normal conditions of service operations with any existing suitable aircraft. Not only is there no present suitable equipment which would carry a payload with safety over this distance, but there is none which could even achieve scheduled operations with no payload at all over such a route. (See Fig. 3.)

Although the shortest over-water distance between North America and Europe, excluding the Arctic route, is that from Newfoundland to Ireland, we do not believe the daily operation over this route possible owing to weather conditions. The only potentially possible route is, therefore, via Bermuda and the Azores, involving an over-water hop between the two mid-ocean points of more than 2000 miles.

From a study of the advancement made in flying characteristics of transport aircraft during the last decade, we find that there is no trend which would indicate the coming evolution in the near future of a type of transport aircraft suitable for transatlantic passenger service with maximum hops of the above distance. Until some radical change in design or methods of operation takes place, such operations would appear to remain impractical for many years to come, if not permanently. We do not consider there to be a reasonable likelihood of such developments. We do not consider landplanes suitable for operation of passenger or mail service on long over-water hops, nor do we regard single-engined aircraft as providing the requisite safety and reliability for such an operation.

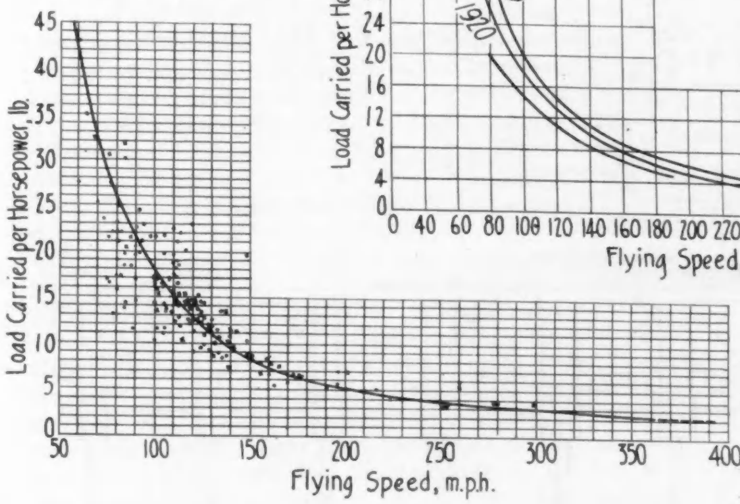


Fig. 1—Airplane Flight-Efficiency Curve Showing Load Decrease with Increase in Speed

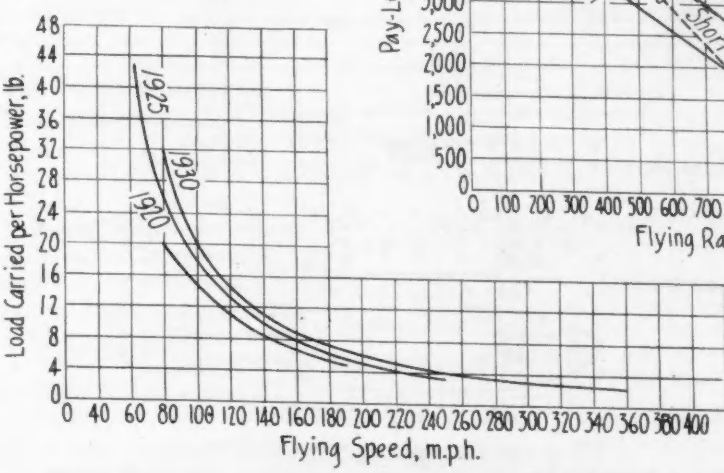


Fig. 2—Similar Curves for 1920, 1925 and 1930, Showing Slight Improvement in 10 Years

Seadrome Is a Deep, Streamlined Truss Structure

An understanding by the reader of the structure and principles of operation of the seadrome is advisable before I attempt to develop the economics of the seadrome ocean-airway operation. Both technicians and laymen have expressed skepticism regarding the feasibility of permanently anchoring a large floating structure in the deep waters of the Atlantic and in general have hazarded the guess that the first real gale would wreck it and, metaphorically, send its foolish sponsors to a watery grave. If a seadrome had any of the characteristics of a large ship I would be in agreement with such an opinion. However, a seadrome is not a ship, subject to the shearing and bending forces of large waves, but is a deep-draft open-work structure constructed so that the wind and waves can pass through it with virtually no disturbance or loss of energy.

The final form of the seadrome is the evolution resulting from 15 years of investigation, designing and testing. Beginning with the first design in 1915, about 20 different types have been made the subject of experiment and study. The basic structure represented in the present design was originated in 1919 and, as finally worked out, follows very closely the fundamental principles incorporated in the first model constructed in 1922. Subsequent tests have confirmed the basic principle of the structure as being the only feasible way of building a floating station suitable for ocean airport service. Therefore the widely held opinion that no other type of structure will successfully serve the purpose and survive under the weather conditions associated with the service seems amply justified.

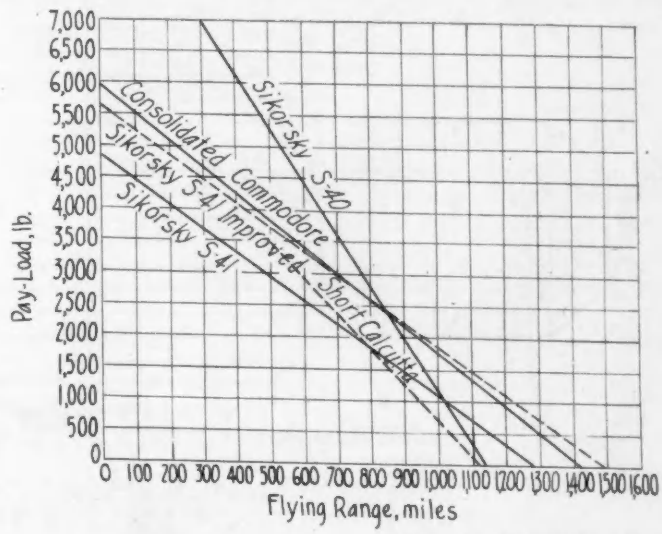


Fig. 3—Payload and Extreme Flying-Range of Flying-Boats and Amphibian Airplanes under Still-Air Conditions

Fig. 4 is an elevation and deck plan of the seadrome, and Fig. 5 shows cross-sections and stability diagrams.

The seadrome deck, which is of steel and stands 70 ft. above the sea level, is 1100 ft. long, 340 ft. wide in the middle zone and 180 ft. wide at the ends. It is supported by 32 buoyancy tanks connected to the deck by means of streamlined iron columns, the whole forming a deep truss composed of tubular struts and steel-cable ties. The buoyancy tanks are arranged symmetrically in four rows, the outer rows being composed

of five tanks, each 34 ft., in diameter, and the central rows of 11 tanks, each 27 ft. in diameter. All tanks are 38 ft. deep. The longitudinal spacing of the buoyancy tanks averages 100 ft. Below the buoyancy tanks, the lower columns extend about 100 ft. to support the ballast tanks, which contain sufficient iron-ore ballast

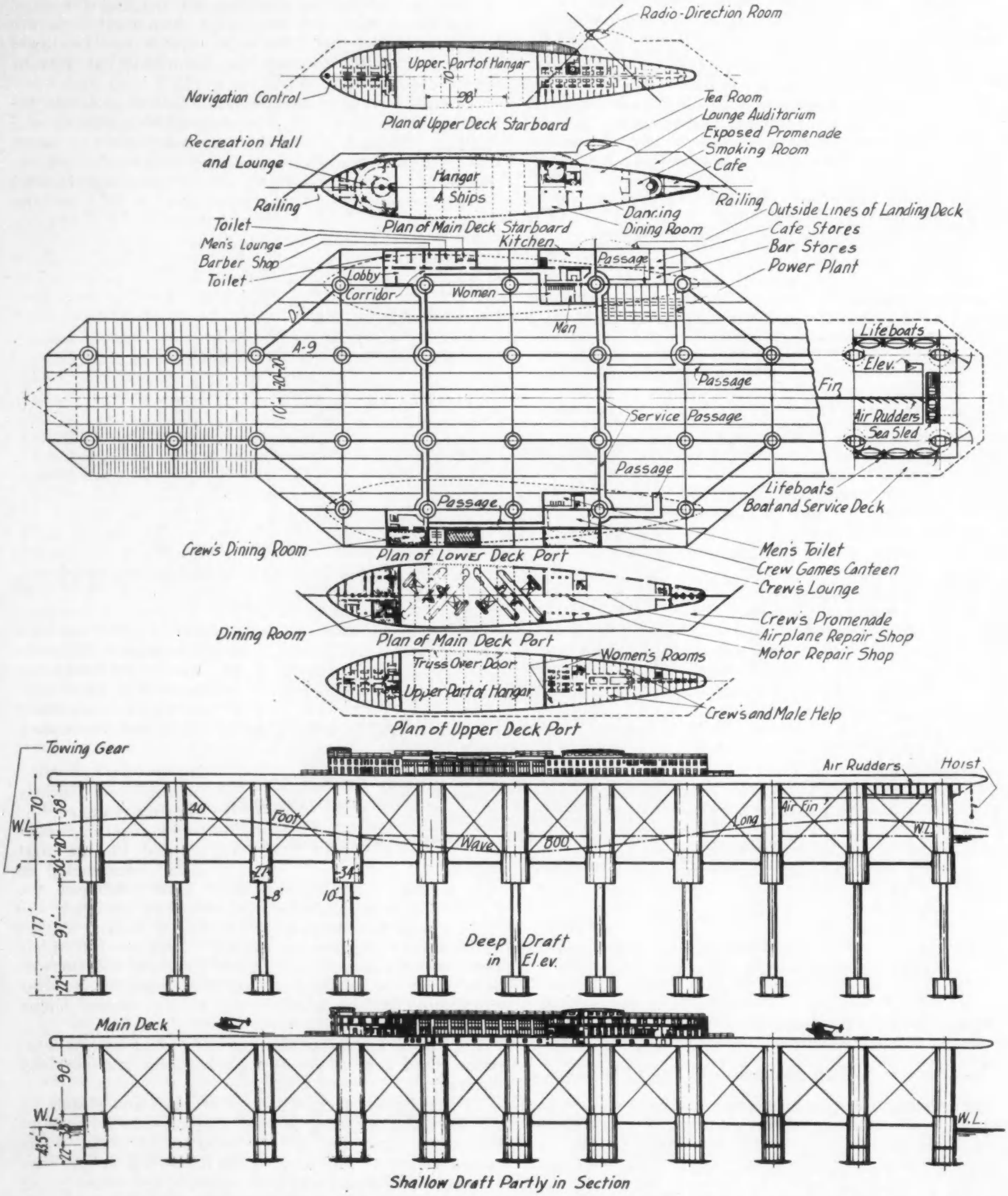


Fig. 4—Plan and Elevation of Seadrome, Showing Relative Draft with Ballast Columns Extended and with Them Telescoped into the Buoyancy Columns

Plans of Upper-Deck and Main-Deck Streamlined Hangars Are Shown Above and Below the Deck Plan of the Seadrome

to bring the center of gravity of the structure as a whole about 10 ft. below the center of buoyancy.

Because of the peculiar arrangement of its elements, a seadrome does not roll, pitch or heave when exposed to wave action. Waves go through the open-work structure without being disturbed or having their orbital movement of propagation broken up, so no energy is released from the wave system and therefore almost no stresses are produced in the seadrome when it encounters the maximum in waves associated with the most severe storms at sea.

All exposed parts of the seadrome in the region of the water line and above it are of streamline shape to reduce wind resistance to the minimum. The system of lower columns is made amply strong so as to avoid the need of struts and ties, which would greatly increase the water-current resistance and introduce considerable complication in erection and maintenance.

The deep-sea draft of the seadrome, on station duty, is 177 ft. Obviously, such a great draft precludes erection close to shore; therefore, to make this operation possible in shallow water, with a draft of approximately 44 ft., the ballast-tank columns are designed to telescope into the streamlined upper columns connecting the buoyancy tanks with the deck. The ballast, ballast tanks and ballast-tank columns, under this condition, are supported by the buoyancy of the ballast tanks.

Structural Design and Materials

The structural weight, as finally worked out, exceeds that estimated in the preliminary design, the total being about 17,500 tons. In general, the deck system has been designed by structural-steel and bridge engineers in accordance with the specifications of the American Institute of Steel Construction. The buoyancy system, designed by naval architects and shipbuilders, is according to American Bureau of Shipping and Lloyds requirements. Soft steel is the principal construction material, and the joints are riveted, the single exception being the deck plates, which are welded. Special rivets are specified in all locations directly exposed to sea water, to minimize corrosion brought about by electrolytic action.

Decks and bulkheads divide the buoyancy tanks into seven water-tight compartments, a total for the whole structure of 224 subdivisions. This number is believed ample to assure adequate buoyancy under all conditions at sea. An electrically-driven bilge pump is provided in each buoyancy tank and connected so as to drain seepage water from any compartment. Provision is also made to use compressed air to clear any compartment of water, should this be necessary. Either the bilge pump or the water system is used to maintain the desired water-line displacement and trim. Any compartment is accessible for maintenance and repair from the inside, special paints being ordinarily used to inhibit corrosion.

The streamlined columns connecting the deck with the buoyancy tanks are made of iron because investigation has shown that iron is very resistant to corrosion by salt water. The life history of anchored lightships has been studied and gives additional support to the opinion that the seadrome structure, when constructed as planned, will not corrode sufficiently to affect its strength or performance during the first 20 years of its life. As the amortization period assumed in the financial set-up is 10 years, that figure seems quite conservative.

Dimensions of the seadrome are those found necessary for stability and safety at sea and exceed those required for airway operation, according to landing and take-off experiments conducted at Roosevelt Field, L. I., from a seadrome area in which a twin-engine Sikorsky amphibian was used. On the average only 60 per cent of the central runway was required for landing and take-off without the use of brakes. In view of the trend to larger airplanes, provision is made in the structural design for lengthening the landing deck at sea by 200 to 400 ft. to an ultimate length of 1500 ft. or more should this prove desirable after some service experience. A considerable increase in length would not materially increase the stresses in the structure because the maximum wave-length encountered at sea is the stress-controlling factor after the length of the floating structure exceeds 1000 ft. From a structural

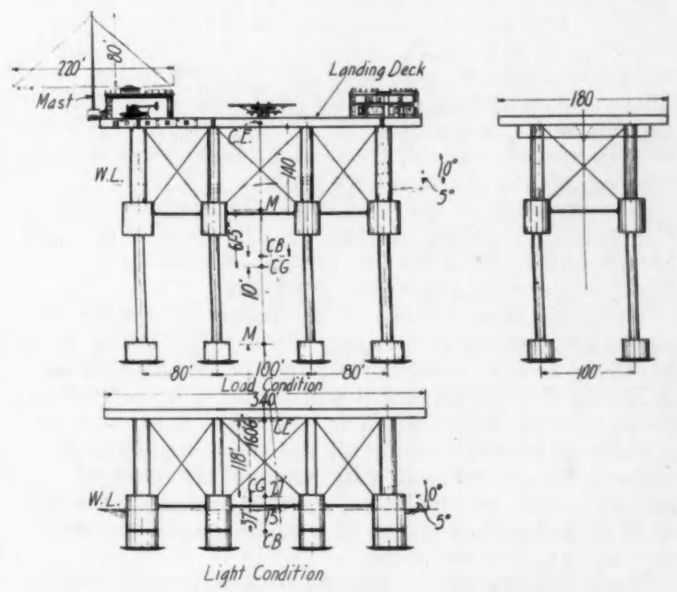


FIG. 5—CROSS-SECTION AND STABILITY DIAGRAMS FOR DEEP AND SHALLOW DRAFT, IN LOADED AND LIGHT CONDITION

The Data Are as Follows:

In Loaded Condition, Deep Draft

Weight	Tons	Buoyancy	Tons
Live Load	1,050	Upper Columns	5,454
Light Weight	26,904	Buoyancy Chambers	13,334
Water in Buoyancy Chambers	4,972	Lower Columns	5,186
Water in Lower Columns	5,450	Ballast Chambers	13,576
Water in Ballast Chambers	9,500	Total	47,876
Total	47,876	Tons per Foot	273

In Light Condition, Shallow Draft

Weight	Tons	Buoyancy	Tons
House Deck and Trusses	7,470	Buoyancy Chambers	13,334
Upper Columns	2,466	Ballast Chambers	13,570
Diagonal Cables	245	Total	26,904
Buoyancy Chambers	3,060	Tons per Foot	617
Pipe Struts	265		
Lower Columns	826		
Ballast Chambers	2,272		
Ore Ballast	9,300		
Total	26,904		
Structural Steel in Legs, net tons	10,877		

Stability

	Loaded	Light
5-Deg-Angle Wind Pressure, ft-lb.	413,728,000	393,376,040
10-Deg-Angle Wind Pressure, ft-lb.	602,873,600	525,736,492
Righting Moment, 5-Deg. Angle, ft-lb.	750,695,680	903,974,400
Righting Moment, 10-Deg. Angle, ft-lb.	1,286,906,880	1,267,153,920

Calculations based on a 100-mile gale; 40 lb. per sq. ft. side-wind pressure.

and stress point of view, a seadrome could be 1800 ft. long, or more if necessary.

Provisions for Hangars, Personnel and Passengers

The design laid down includes hangars and personnel space on both sides of the deck, but limiting the hangar space to one side and providing personnel quarters in the deck system where there is ample room is feasible and less costly, at least until the test period has been successfully passed. This would make available a much greater width of deck for landing the larger planes that may be developed and put in operation in the near future.

Hangar space is 70 ft. wide by 180 ft. long, with a clearance of 24 ft. at the entrance, which is 98 ft. wide. Repair shops and equipment are provided and ample lighting and power apparatus are specified, power being supplied by two three-phase 60-cycle 350-kw. gasoline-electric generators. Two air compressors having a capacity of 400 cu. ft. of free air per minute are included to provide compressed air for freeing the buoyancy compartments of water and operating the air breakwater. Compressed air is also used to maintain service pressure on the fresh-water tanks located below the sea level in the buoyancy tanks.

Gasoline and oil are also stored in compartments in the buoyancy tanks, delivery to the deck being controlled on the Aqua Marine system of gasoline storage, which eliminates all danger from fire.

Hotel facilities include 40 bedrooms for guests and ample accommodations during the day for 350 or more in the various lounges and public rooms planned. Quarters for the personnel will, in part, be located between the top and bottom of the main deck, the area being sufficient to provide all the space required. Lifeboats sufficient to seat 240 persons are part of the safety equipment, including a 54-ft. sea-sled, capable of 30 to 40 knots speed, to be used for patrol and rescue service from the seadrome.

Flood lighting of the landing deck will make landing and take-off of planes at night as safe and reliable as in daylight. Searchlights visible for from 50 to 100 miles are provided as an avigational aid, although the radio-beacon system to be installed is so simple and reliable that no other directional assistance seems to be necessary.

Avigation Control and Communication System

A safe and practical system of ocean airways could not be brought about even with the facilities offered by anchored seadromes if it were not possible to provide reliable and efficient radio directive avigation and communication aids. The General Electric Co., with the assistance of the Bureau of Standards, has worked out a complete system of avigation control by means of the radio beacon, radio telephone and telegraph communication and instrument equipment for seadromes, land terminals and transport planes. The system recommended will assure accurate directional avigation and continuous two-way communication with the seadrome or the land terminals by the planes operating over the system under all weather conditions. Such a result is made possible because of the relatively short distances between the land terminals and the seadrome. The system includes two separate methods of avigation, one magnetic and the other by radio. They may be used effectively either jointly or independently.

A radio-operated visual route-indicator of the vibrating-reed type on the plane makes accurate avigation possible irrespective of weather conditions or the direction or strength of the wind, the pilot having no other duty than to watch the route indicator and operate the airplane. The radio operator carries on all communication with other planes, seadromes or terminals, and transmits or receives instructions or information sent out for the guidance of the pilot by the dispatchers under whose directions all planes will operate. Both long and short-wave radio equipment will be installed, making it possible, if necessary, for passengers to communicate with ships at sea or with the land telephone system.

To compensate for the swing of the seadrome around the anchorage system, the goniometer element controlling the direction of the radio beam is connected to a Sperry gyro-compass according to methods worked out by the engineers of the Sperry Gyroscope Co., so that the signal beam will always be maintained constant in direction.

Although the central zone marked out by the radio beam assures avigation that is correct to within 1 or 2 deg., deviation from the main route to avoid squalls or local storms can be made to angles exceeding 25 deg. on either side without decreased intensity of reception of the signals received. This means that a plane at mid-point between the land terminal and the seadrome may be as much as 75 miles off the main route on either side and still receive standard signal-strength identifying for the pilot his position and direction from either the terminal or the seadrome. Main reliance will be placed upon radio avigation aids to assure accurate avigation, but standard equipment specified by the Department of Commerce for airplanes operating over water will also be installed as a reserve system.

Patrol boats, of the Coast Guard type, equipped with radio-communication sets, will operate from land terminals and always be ready at any time to go to the rescue of planes forced down at sea. The seasled provided at the seadromes gives the same service, so a disabled plane, forced down at the mid-point, can be reached in 4 to 5 hr., and on the average in half this time. Radio phones, and in emergencies radio-telegraph signals, will guide the patrol boats to the planes, which are provided with emergency equipment to be operated on the surface of the ocean.

As an additional avigation safeguard, the seadrome is provided with the standard marine-type radio-compass receiver, which can be used to give bearings to ships and shore stations by means of the long-wave radio phone on the wave band that has been assigned to shipping.

Fabrication and Erection of the Seadrome

The seadrome, exceeding as it does the dimensions of any floating structure now built, has been designed so as to be simple in construction and easy to assemble with facilities ordinarily available; hence its great size does not involve any more expense in fabrication and erection than is usual in structural-bridge and shipbuilding practice. The deck system, or superstructure, is a structural-bridge design of the truss type involving no special stresses or sections. The buoyancy system, or substructure, requires a combination of shipbuilding methods and tank-shop practice for its fabrication. The tank units, with their connecting columns and struts, will be fabricated on marine ways and launched, after which they will be towed to the assembly point in Dela-

ware Bay, approximately 10 miles west of Cape May, N.J.

The general plan worked out for the assembly calls for fabrication of the deck trusses and the floor system to start simultaneously with the construction of the buoyancy units. As planned, the buoyancy tanks will be built by the Sun Shipbuilding Co., of Chester, Pa., and companies associated with it in the work, producing among them four units every 30 days. The Belmont Iron Works, of Philadelphia, will construct the necessary deck system to go with one section of two tanks every 15 days.

The first four tanks will be assembled in skeleton form under the League Island Navy Yard crane to give a platform on which to locate the erection derricks necessary to complete the rest of the structure at the Delaware Bay assembly point, to which the first unit will be towed and where it will be anchored when completed. Deck structural material and additional buoyancy units will be barged and towed to the erection site, the assembling of the structure being completed in the shallow-draft condition.

The assembly location chosen is about 10 miles west of Cape May, N. J., near the 39th parallel of north latitude. It is about 8 miles north of Lewes, Del., and about 5 miles east of the Delaware shore. A maximum water depth of 44 ft. is required for erection, so ample clearance is assured at the erection site where the water, on the average, will be 70 ft. deep. The location, in addition to being in relatively deep water, is out of the main ship channel and the work will therefore at no time be a menace to navigation.

The time required to complete the first seadrome is estimated at about one year. Complete test of all equipment, including the radio aids and the landing and taking off of loaded planes, will be made before the seadrome is towed out to sea.

Arrangements for the Supply Service

An important feature of the seadrome operation is the supply service, by means of which all the operating materials and supplies are delivered to the dromes by ships specially adapted for this service. Gasoline and oil will be delivered by tankers to supply tanks in the buoyancy units below sea level at the stern of the seadromes. The supply ships are, when necessary, to be protected from waves by air breakwaters which effectively destroy wave motion through diffusing compressed air from perforated pipes. The air is released from the ballast-tank system about 160 ft. below normal sea level, so that the rising bubbles break up the waves, reducing a 30-ft. wave to a minor turbulence. A safety zone about 250 x 600 ft. will be maintained by this method when servicing operations are going on, should it be necessary. By the use of this system, supplies can be transferred from ship to drome under virtually all weather conditions met with at sea. The same system can be used when refueling flying-boats that are too large to land on the deck or be hoisted to it by the derrick equipment.

While the seadrome system is normally designed for amphibian-type airplanes capable of descending on the water or on the land as the conditions may require, the landing of multi-engine landplanes on the deck is feasible, as is also the refueling of the largest flying-

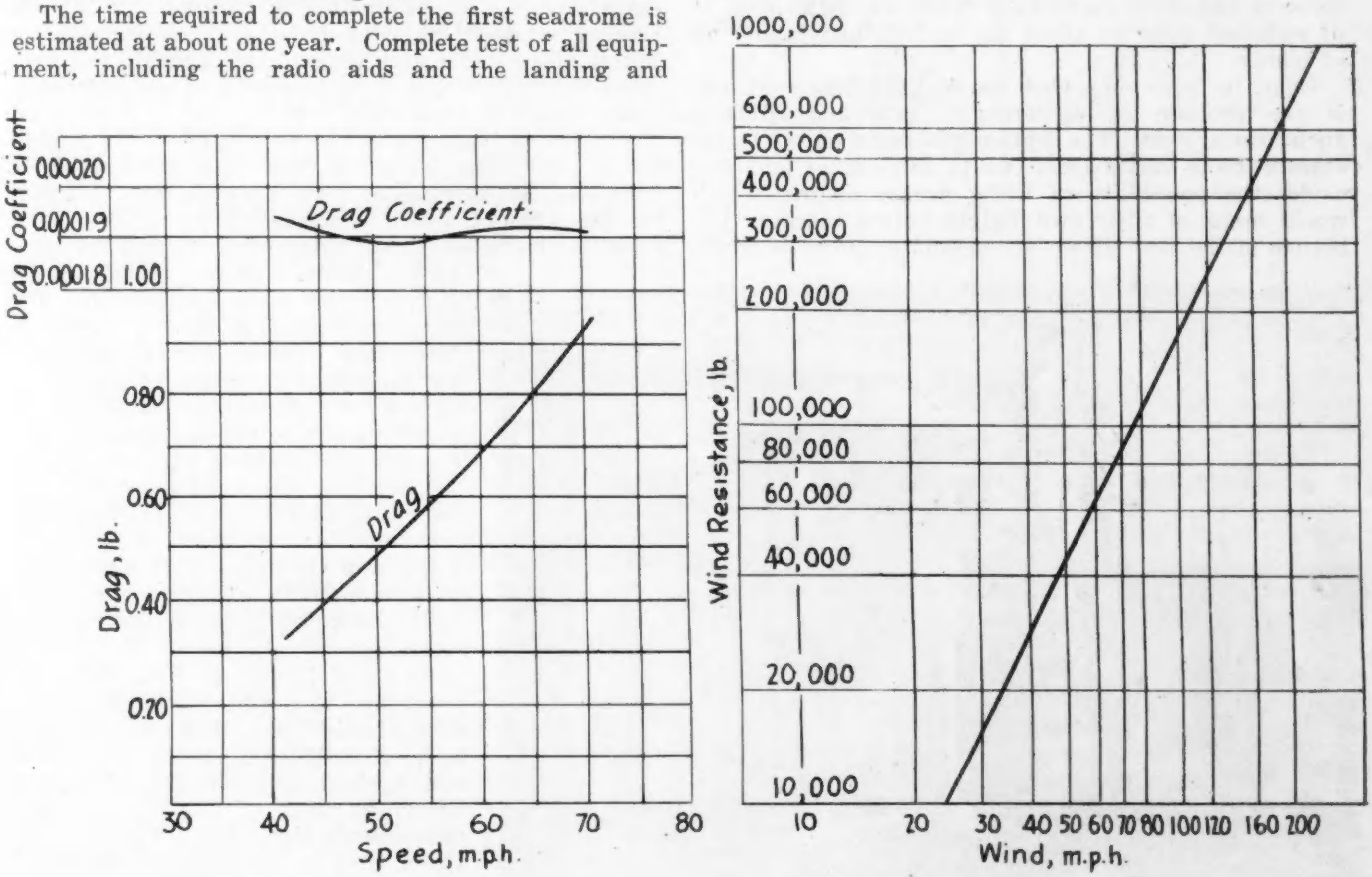


FIG. 6—RESULTS OF WIND-TUNNEL TESTS (LEFT) OF SEADROME MODEL AND COMPARATIVE RESULTS OBTAINED UNDER NATURAL WIND-CONDITIONS (RIGHT) WITH 1/32-SCALE MODEL

The Drag Tests Were Made at the Daniel Guggenheim School of Aeronautics at New York University in a 9-Ft. Wind-Tunnel at a Wind Velocity of 50 M.P.H.

boats in the artificial harbor provided by the compressed-air system. Undoubtedly all three types of plane will be developed and used, because of their special fitness for certain forms of service required on the transatlantic route. Refueling in the air from a seadrome obviously will be a practical and efficient procedure in cases in which it is desirable to make the flight a continuous one.

Anchoring and Holding Seadrome into Wind

An anchorage-gear towing connection is attached to the two forward buoyancy tanks in line with the lower chord of the main truss system making up the seadrome. The method of attachment distributes the anchorage stress throughout the structure. The connection is designed so that the cable connecting with the anchorage buoy can be led through it to the tension engine, located in the power area. Slack in the connecting cable can be taken up automatically by operation of the engine, thereby preventing the cable fouling the submerged portion of the seadrome.

Fin areas are provided at the stern so as to bring the center of wind pressure aft of the center of water pressure, thereby causing the seadrome to trail into the wind at any wind velocity in excess of 15 m.p.h. This condition of operation is necessary for the safe landing and take-off of planes. Air rudders are provided to prevent yawing after coming up into the wind. These are operated electrically and are controlled automatically by a damped wind-vane. The rudders hold the seadrome into the wind, irrespective of the direction or force of the ocean current, at times when the wind is of sufficient force to affect the landing and taking off of planes.

Equal in importance with the design of the seadrome is the problem of providing a safe and effective anchorage system. The depth of the ocean on the transatlantic route varies from two to three miles and precludes the possibility of using anchor chains, which would break of their own weight before reaching the bottom of the sea. However, an entirely feasible method is to use standard steel cables of the suspension-bridge type, which are capable of supporting their own weight in lengths exceeding 40,000 ft.

Experiments have shown that the total resistance of the seadrome will at no time exceed 200,000 lb. when subjected to the maximum forces of the winds, waves and ocean currents. The resistance that would be encountered was determined mainly by model experiments in a wind tunnel and in the more direct and obvious way of measuring wind forces on a large floating model exposed to winds of various velocities. Water-current resistance has, in the main, been calculated on the basis of resistance factors long established and accepted as standard in naval architecture and marine engineering. According to these calculations, the current resistance will total about 35,000 lb. with a 1½-knot current, which is the maximum expected at the anchorage site. Besides the surface current usually met by ships, undoubtedly some submarine currents exist that extend probably to depths exceeding 2000 fathoms. From data available the velocity of these submarine currents is estimated to in no case exceed ½ knot per hour. The resistance of the anchoring-cable system has been calculated on the basis of this velocity added to the current resistance of the seadrome.

Wind-Resistance Tests and Calculations

An analysis of the weather conditions that may be expected at the anchorage site has been checked by Dr. James Kimball, in charge of the New York City division of the Weather Bureau, who has made a special study of Atlantic weather in connection with forecasting weather for almost all of the transatlantic flights attempted. According to Dr. Kimball, the maximum wind velocity will be about 70 m.p.h., occurring in the month of November.

Wind-tunnel experiments were conducted late in 1928 on a 1/300-scale model at the Daniel Guggenheim School of Aeronautics at New York University under the direction of Prof. Alexander Klemin. The wind velocities employed varied from 40 to 70 m.p.h. Some of the results obtained are shown by Fig. 6, which gives the resistance and the drag-coefficient curve determined. The latter is asymptotic and therefore no correction for scale effect is required in converting wind-tunnel-model results to full-scale values. According to the curve, the wind resistance of the full-sized seadrome will be about 85,000 lb. at the expected maximum wind velocity of 70 m.p.h. This result is in practical agreement with those obtained from the model tests conducted under natural conditions.

As an additional check on the wind resistance of a full-size seadrome as determined from the wind-tunnel tests, a 1/32-scale model was made and anchored out in the Choptank River, an arm of Chesapeake Bay, near Cambridge, Md. This model, shown in Fig. 7, was very accurately made to scale, weight and strength, so that the results of exposure to wind, waves and currents would, in addition to giving accurate resistance, give

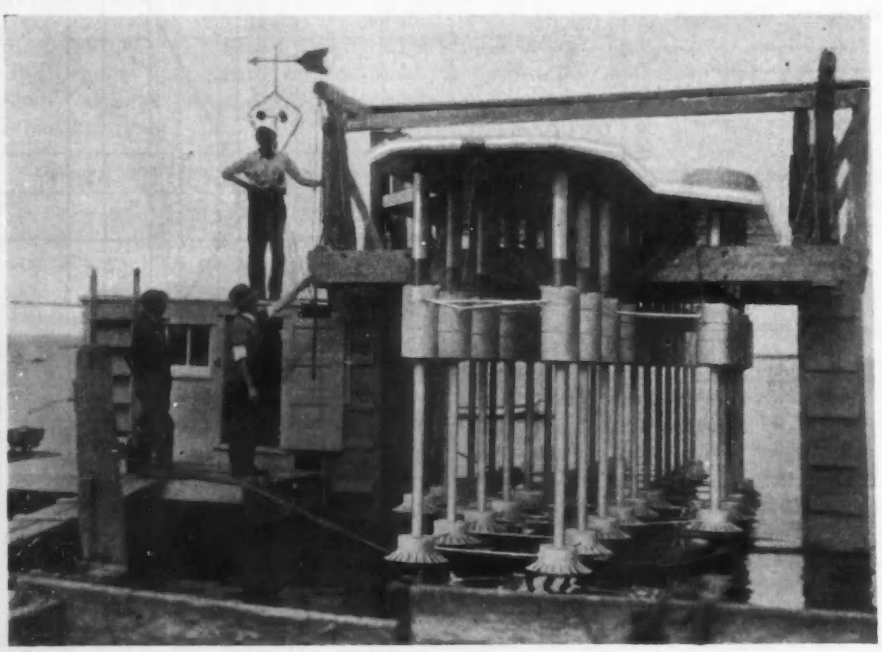


FIG. 7—SEADROME MODEL, 35 FT. LONG, TESTED IN CHESAPEAKE BAY TO DETERMINE ITS PERFORMANCE

fairly complete performance data that would check model performance previously obtained with much smaller models. It was made of sheet steel and is 35 ft. long, 10½ ft. wide and has a draft of about 6 ft. It weighs, in the deep-draft condition with all water ballast in place, 3500 lb., equivalent to about 50,000 tons in the full-sized structure.

The experimental test period covered about six weeks, during which a wide variety of weather conditions prevailed. Wind reached a maximum of over 50 m.p.h., with accompanying waves measuring 4 to 4½ ft. from trough to crest. The wind resistance over a wide range was accurately measured by dynamometers, and, when interpreted and developed to apply to the full-size structure, proved to be in very close agreement with the wind-tunnel results. A resistance curve drawn from these tests is given at the right in Fig. 6. This shows that at 70 m.p.h. the resistance is about 85,000 lb. When corrected for scale relationship, a wind velocity of 50 m.p.h. on the model is equivalent to a wind of 280 m.p.h. on the full-size seadrome, and 4½-ft. waves to 144-ft. waves on the seadrome.

The performance of the large model under natural conditions checked very exactly the performance of the smaller models previously tested in gravity-made and controlled waves. We had no reason to expect contrary results, and it is reasonable to expect the full-size structure to perform relatively the same.

Anchorage System as Worked Out

The anchorage system finally worked out terminates in a large reinforced-concrete anchor of a spherical segmental shape, 100 ft. in diameter and weighing approximately 1500 tons. It is provided with a buoyancy compartment which in effect makes it a concrete boat and gives it sufficient buoyancy so that it can be towed to the anchorage site, flooded and sunk with its connecting cable. The mass and shape are such that it will not move horizontally or turn over under the maximum stress transmitted to it by the seadrome. A cross section and plan are shown in Fig. 8.

Two parallel 150-ft. lengths of steel anchor-chain are attached to the anchor, and to these are fastened the galvanized-steel anchor-cables made up of six sections varying in diameter from 2¾ in. at the bottom to 3¾ in. at the top. The chains connect to the anchor by means of a swivel to prevent twisting of the chains or cables, which might be caused by rotation of the seadrome or the anchorage buoy. To compensate for possible wear by contact with the bottom of the ocean, the terminal cable section is increased in diameter to 3½ in. Chain rather than cable is used at the anchor connection to minimize wear and avoid kinking of the cable or fouling of the anchor. The cable diameter increases as the cable approaches the surface so as to give a uniform factor of safety throughout its length.

The general arrangement of the anchorage is shown in Fig. 9. The surface ends of the cable connect with the anchorage buoy through a centrally mounted steel shaft supported by both radial and thrust roller-bearings. To the anchorage buoy is fastened the seadrome connecting cable, 3¼ in. in diameter and about 500 ft. long, the seadrome end attaching to the towing gear in such a way that it can be hauled up under the seadrome deck by the tension engine provided, which is regulated to maintain a minimum tension of 5000 lb. on the connecting cable so that under no condition can it

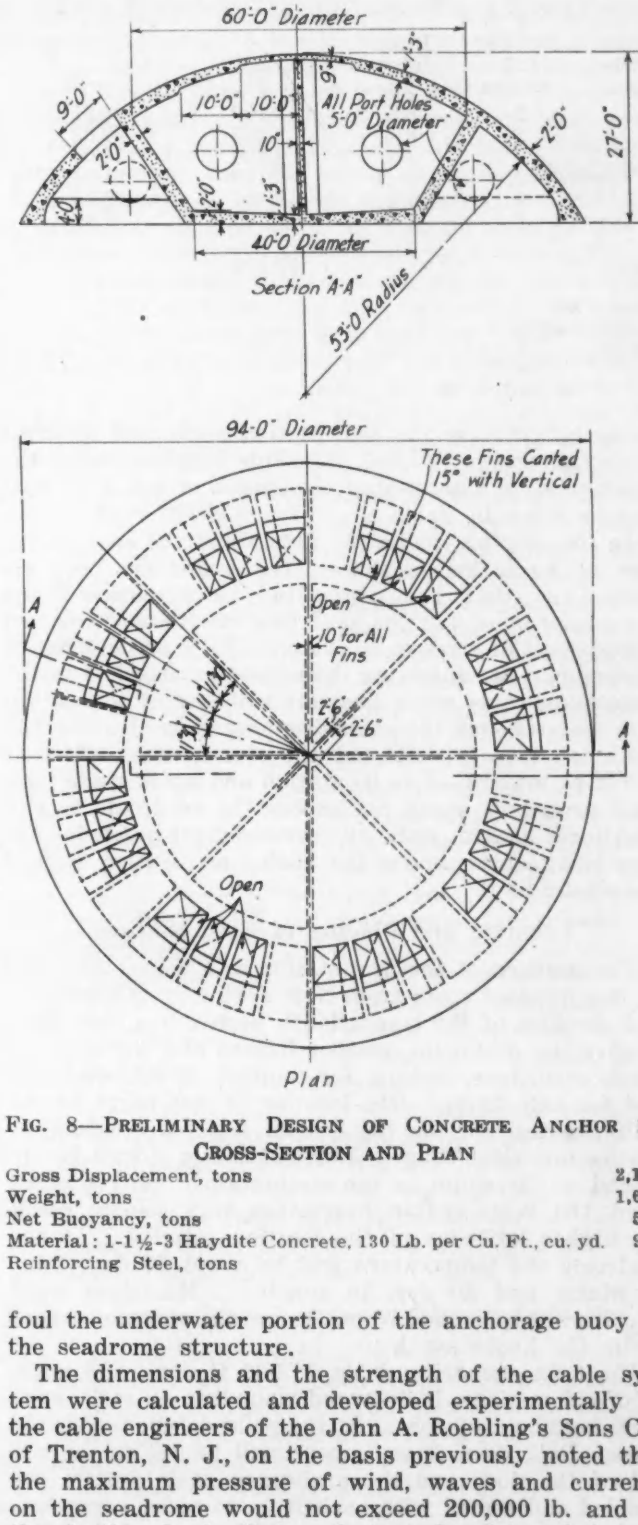


Fig. 8—Preliminary Design of Concrete Anchor in Cross-Section and Plan

Gross Displacement, tons	2,165
Weight, tons	1,660
Net Buoyancy, tons	550
Material: 1-1½-3 Haydite Concrete, 130 Lb. per Cu. Ft., cu. yd.	945
Reinforcing Steel, tons	57

foul the underwater portion of the anchorage buoy or the seadrome structure.

The dimensions and the strength of the cable system were calculated and developed experimentally by the cable engineers of the John A. Roebling's Sons Co., of Trenton, N. J., on the basis previously noted that the maximum pressure of wind, waves and currents on the seadrome would not exceed 200,000 lb. and on the further basis that a factor of safety of 4 to 1 would be ample in the final design. Because a single cable would require cable sizes in the upper sections greater than that ordinarily produced by the cable manufacturers, a twin-cable system was decided upon to avoid the expense of special equipment. Obviously, three or more cables can be used should this appear desirable, either to increase the factor of safety of the anchoring system or to provide for anchoring at considerably greater depth.

The ocean depth in the vicinity of the location tenta-

TABLE 1—TWIN-ANCHORAGE-CABLE DATA, FOR NORMAL SEADROME DRIFT OF 200,000 LB.

Section	Number of Cables	Diameter, In.	Length, Ft.	Weight, Lb. Per Ft.	Weight, Lb. Total Air	Weight, Lb. Total Water	Ultimate Strength, Lb.	Cable Stress, Lb.	Factor of Safety
1	2	3¾	2,150	23.81	102,400	89,000	2,300,000	600,000	3.83
2	2	3½	2,450	20.82	102,000	88,400	2,000,000	516,000	3.88
3	2	3¼	2,800	18.00	100,800	88,800	1,736,000	436,000	3.98
4	2	3	3,100	15.50	96,000	84,400	1,448,000	359,600	4.03
5	2	2¾	3,700	12.70	94,000	81,600	1,240,000	293,200	4.23
6	2	3½	3,700	20.82	154,000	123,600	2,000,000	240,000	8.33
Total			17,900		649,200	555,800			
Seadrome Connecting Cable	1	3¼	500	19.79	9,895	7,928	868,000	200,000	4.34

tively selected for the first station anchorage is about 2100 fathoms, or 12,600 ft. This is accordingly the depth used in determining the length of the cable system as given in Table 1.

In considering the safety factor and the safe operation of the anchorage system, the design has been arranged so that the connecting cable between the anchorage buoy and the seadrome can be disconnected in the event of stresses on it exceeding a predetermined maximum. A registering dynamometer attached to the connecting cable gives adequate warning of this situation and releases the cable-dropping gear, leaving the seadrome free to drift out the storm, after which it would be towed back to its station and again made fast. This procedure would not expose the seadrome to any additional hazard, while the arrangement precludes the possibility of stressing the anchorage system beyond the elastic limit.

Location and Placing of First Station

The position of the first station as a connecting stop on the proposed route from New York City to Bermuda, and the first of the transatlantic series, has been fixed to give the minimum weather hazard and the best climatic conditions, making for comfort on the seadrome and for safe flying. The location is just north of the Gulf Stream, outside the coastal fog zone and below the ice and sleet range. North Atlantic storms rarely extend as far south as the station site. On the other hand, the West Indian hurricanes very seldom reach the higher latitudes of the location selected. At the seadrome the temperature will be about 60 deg. fahr. in winter and 80 deg. in summer. Maximum wind velocity will be around 70 m.p.h. and the surface current about 1½ knots per hour.

The twin anchoring cable, 17,900 ft. long and made up of six sections, is delivered wound up on reels, each weighing about 30 tons. At the point selected, possibly Lewes, Del., derrick equipment will be set up at the end of the dock and the anchorage cable system assembled and coated with asphaltum to resist corrosion. The surface ends of the cables will be connected to the anchorage buoy and payed out, being supported by pontoons at 500-ft. intervals. The first 1000 ft. of the cables below the anchorage-buoy terminal is protected from corrosion by the asphaltum-impregnated jute and tape covering. The remainder of the cable system is spray coated with 1/16 in. of asphaltum as it is unreeled, paid out, joined and buoyed before being towed out. Below the 1000-ft. depth, the oxygen content of sea water is so small that corrosion virtually does not occur.

After being towed out to sea, the completely connected anchorage-cable system, supported by the temporary pontoons, will be extended in a straight line by large tugs, so located that when the cables are simultaneously released from the supporting pontoons by electrical mechanism and the anchor allowed to sink to the bottom, the anchorage buoy will be maintained in its correct position by sights on the marker buoys. By this method of lowering, the anchorage-cable system comes to rest gradually and progressively without undue shock, and the anchor finally reaches the bottom at the location selected. Estimates indicate that about 30 min. will be required for the anchor to reach the bottom of the ocean after being released.

Fortunately, the prevailing winds off the coast in the vicinity of the Delaware Capes are from the southwest, which greatly simplifies the problem of towing out the seadrome after erection is completed. Two large ocean-going tugs are estimated to be ample to tow the seadrome to its anchorage at the rate of about 4 knots, and the towing-out period may require from three to five days. The prevailing ocean currents will, in general, assist the tugs. Upon arrival at the anchorage and making fast, the ballast tanks will be successively flooded to bring the seadrome to a service draft of 177 ft. It is then ready for operation.

The development of a suitable anchor has been the subject of considerable experimenting and testing. Information accumulated in an exhaustive search of original sources, very definitely showed that in the general vicinity of the first seadrome anchorage the bottom of the ocean is composed of red clay overlaid with 2 ft. of ocean ooze. This conclusion seems amply justified in view of the recent samples of the ocean floor obtained by the cable-repair ships during the repairing of telegraph cables broken by a considerable subsidence of the ocean floor off the Newfoundland and Nova Scotia banks.

Red clay is ideally suited to a permanent anchorage, such as is contemplated for the seadrome service, provided the anchor is firmly imbedded in it. The soft covering of ooze will cause very little abrasive action on the cables, while the smoothness of the bottom and the absence of rock formation of any character will virtually eliminate fouling.

A satisfactory anchor must incorporate in its design an anchor connection capable of swinging around the horizon with the swing of the seadrome and be equally effective and non-fouling in all directions. The final form selected, after experimenting with more than a dozen types, including several of standard design, is that already described and shown. Experi-

mental results obtained indicate that an anchor of this type, weighing 1500 tons, will have an ultimate resistance considerably in excess of 1,000,000 lb.

The North Atlantic Airway Route

The economic necessity for service stations on the Atlantic route has been demonstrated. Aside from economy in operation, their use is imperative for safe airplane operation. The hazard of weather is the chief menace to the airway operator, accounting on the airmail lines for more than 95 per cent of the failures to start or complete trips.

On the Atlantic route the usual steamship voyage of six to nine days runs the whole gamut of weather changes. In the high-speed crossing, the airplane must be subjected to the same weather variations spread over the 3000 miles of ocean as the slower ship, except that storm and calm will succeed each other with much greater frequency because of the quick passage. Because of this quick succession, the weather has been almost the sole hazard of present airway operation, both over land and sea.

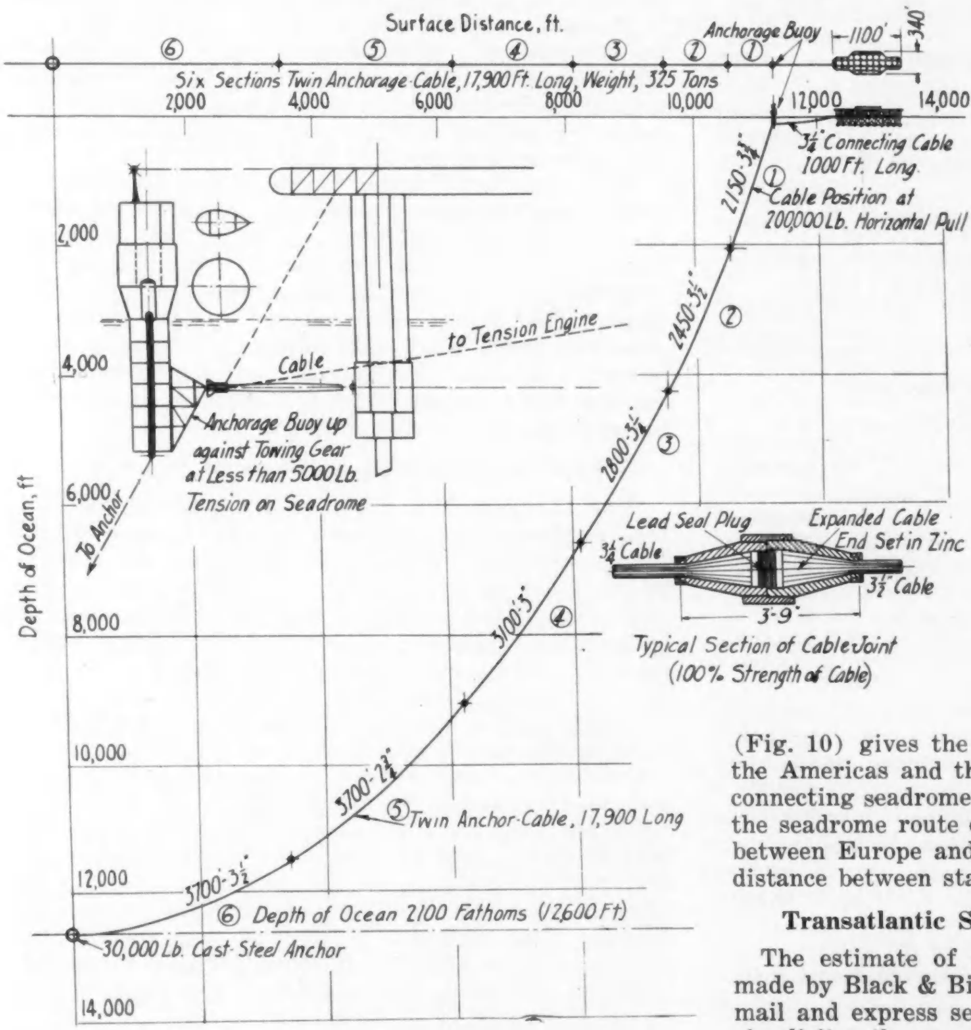


FIG. 9—TWIN-CABLE ANCHORAGE ARRANGEMENT

The Twin Cables Are in Six Sections Aggregating 17,900 Ft. in Length and Increasing in Diameter toward the Surface of the Sea. At the Upper Left the Anchorage Buoy Is Shown Drawn Up against the Towing Gear of the Seadrome by Means of a Cable to a Tension Engine That Maintains a Tension of 5000 Lb.

Only a little study of the Pilot Charts of the North Atlantic, as issued by the Hydrographic Office, is necessary to ascertain that the airway between Europe and America must, from a weather point of view, be located very much south of Newfoundland and somewhat south of the regular transatlantic steamship lane. The more southerly route that has tentatively been selected will, to a very large extent, avoid the storms, ice and fog so prevalent at all seasons of the year on some portion of the steamship lanes. The route selected, shown in Fig. 10, has been specially located south of the "cold wall," so that ice formation on the stations or the planes at the lower levels will be impossible. This route is entirely outside the field-ice zone and iceberg-drift range and will be subjected to less than 10 per cent of the cyclonic storms to which the more northerly shipping lanes are subjected. Dangerous storms are most frequent on the North Atlantic route in the month of October. The airway route laid down has been selected to avoid weather hazards as far as possible.

The route chart shows that when freezing temperature prevails at the New York City terminus the air temperatures at the various seadromes range from 45 to 52 deg. fahr. Fog conditions, which are almost of daily occurrence on the steamship tracks at certain seasons, will be encountered on the selected air route with less than 5 per cent of the frequency experienced by the transatlantic passenger liners.

The seadrome route-map (Fig. 10) gives the present airways of Europe and the Americas and their relationship to the proposed connecting seadrome routes. As is obvious from this, the seadrome route offers direct air-service facilities between Europe and America, with a normal flight-distance between stations.

Transatlantic Seadrome Airway Operation

The estimate of such a transatlantic service, as made by Black & Bigelow for a combined passenger, mail and express service, is here summarized. For simplicity, the operation is figured as that of one company rather than the various international services that undoubtedly would make up the final operation.

The justification for the assumed passenger and mail volume was found in the total of these items in the years since the passing of the World War depression, as given in Fig. 11. The first-class-mail-rate surcharge for air mail is placed at $4 per lb., or 10 cents per letter. The passenger rate is fixed at $350 as being a rate that will attract the traffic necessary to produce the volume estimated and is somewhat lower than the average first-class rate charged on the fast steamships. The Black & Bigelow estimate in part, follows:

Schedule B

This schedule contemplates a daily air-mail and passenger service between New York City and Brest, France, with 10 trips per day in each direction. The equipment upon which these estimates have been based are Sikorsky S-40 amphibians. As under Schedule A we have assumed no cancellations of trips for weather conditions but have provided for sufficient equipment to take care of such delays as may become necessary in the course of the year-to-year operation, it is possible to allow for 3650 round trips per year. Mail revenue is based upon $4 per lb., with a total load of 4000 lb. per day in each direction. Passenger traffic is estimated at 80 per cent of the remaining load of the airplane, or a total average of 465.6 passengers per day. The net fare has been fixed at $350 per passenger.

Estimated Investment

Airports and Flight Equipment	
8 Seadromes, in place	$32,000,000
3 Land Stations	1,200,000
160 Sikorsky Amphibian Airplanes, at $190,000 each; 250 Spare Pratt-Whitney Hornet B Engines, at $7,000 each	32,150,000
Organization and Introductory Cost	500,000
Working Capital, provided on loan basis at 6 per cent	26,820,000
	$92,670,000

Estimated Annual Operating Cost

Depreciation and Obsolescence	
Seadromes and Land Stations	$1,720,000
Flight Equipment	11,769,270
Insurance	
Seadromes and Land Stations	996,000
Flight Equipment	6,751,500
Miscellaneous	513,030
Maintenance and Upkeep	
Seadromes, Land Terminals and Equipment	1,500,000
Flight Equipment	3,115,700
Additional Indirect and Fixed Costs	
Seadromes and Land Stations	1,000,000
Administrative	300,000
Line Service	20,251,000
Traffic Division	850,000
Miscellaneous and Incidentals	4,879,500
	$53,644,000
Unit Costs per Scheduled Mile	$1.95
Unit Costs per Scheduled Hour	195.00

Estimated Annual Operating Revenue

Performance Characteristics of Sikorsky Model S-40 on 400-Mile Range	
Useful Load, lb.	11,250
Crew, Extra Equipment, Gas and Oil, lb.	5,030
Payload, lb.	6,220
Average Payloading per Plane, 80 per cent of capacity	
Schedule (as previously estimated) 10 round trips per day	
Mail, 4000 lb. per day in each direction, or 400 lb. per plane trip, leaving 5820-lb. capacity for passengers	
Mail Revenue, 8000 lb. at $4 per lb., 365 days	$11,680,000
Passenger Revenue, at 80 per cent of capacity or an average of 23.28 per trip, giving 465.6 passengers per day for 365 days, 169,944 at $350 per passenger	59,480,400
Total Gross Income	$71,160,400

Assuming that working capital can be provided by loans, approximately $1,620,000 will be added to the operating cost in the form of interest, making that item $55,264,000. The gross income totaled $71,160,400, the difference giving $15,896,400 to apply against a total investment of $65,850,000. This is equal to a return of about 24 per cent per annum. A 50-per cent increase in traffic will increase the capital investment only 25 per cent but would add 50 per cent to the net income, increasing the annual return to approximately 38 per cent on both seadrome and airway equipment.

That the seadrome proposal will be a very attractive financial operation, granted sufficient business is forthcoming to require ten round trips per day across the Atlantic as estimated, cannot be seriously questioned. It is equally obvious that operation on such a scale can be expected only after several years of experience. Therefore it is pertinent to develop the financial balance sheet for the minimum operation, estimated at one round trip per day, carrying only first-class mail or some few passengers at the mail rate.

It is somewhat startling to realize that the relatively tremendous investment required to establish the eight-ocean-station seadrome route can be justified by one return trip per day over the system, using the smallest amphibian plane suitable for service over the open ocean. That several other national routes, besides the American route, would take advantage of the facilities offered is certain. The Black & Bigelow estimate covering the minimum operation contemplated is given on the next page for comparative purposes.

Experimentation Shows Program Practical

With the growth of the seadrome ocean-airway system, airplane speeds undoubtedly will increase so that future schedules will be about 24 hr. for the trip between America and Europe, eventually carrying the great bulk of the passenger, mail and express business between the continents. The worldwide interest in the seadrome development justifies the inclusion in this report of much information and many data not directly applicable to the specific undertaking contemplated in building and operating the seadrome system.

Following a long period of personal investigation and experimentation beginning in 1913, the Armstrong Seadrome Development Co., of Wilmington, Del., was incorporated in 1926 to develop the feasibility of establishing ocean airways on the seadrome system. In 1928 the Founders Syndicate of Armstrong Seadrome Airways was organized to continue the development program and, in addition, if found feasible, to design, build and operate the first seadrome on an experimental airway between New York City and Bermuda, located so as to be available as the first of the series necessary for the transatlantic route.

A comprehensive experimental program was laid down which it was hoped would confirm previous work and establish with more certainty the belief in the commercial attractiveness of the proposal as well as the engineering practicability of the project. This experimental program, undertaken as part of the development work, has been concluded. The information obtained has very definitely shown that designing, building and operating a seadrome airway-system over the Atlantic is a practical engineering project and one very much worthwhile from a commercial aspect. This is especially gratifying in that the seadrome system is the only method so far proposed for a commercial airway

Operations Analysis

Route Mileage, New York City to Vigo, Spain, via Seadromes	3,571
Round Trip Mileage	7,142
Scheduled Mileage per Year, 365 days	2,606,830
Service Mileage per Year; 3 per cent for ferry, test and search flights	2,737,172
Service Flying Time per Year, 110 m.p.h. average cruising speed, hr.	24,883
Engine Hours per Year, two engines per plane	49,766
Major Airplane Overhauls per Year, 1 per 1000 service hours	24.9
Complete Engine Overhauls per Year, 1 per 250 engine hours	199
Flying Time per Trip, at 110 m.p.h., hr.	32.45
Elapsed Time per Trip, allowing 9 ½-hr. stops, hr.	36.95
Eastbound Airplanes en Route per Day, 2; Westbound, 2	4
Line Airplanes Undergoing Servicing, per day	4
Reserve Airplanes, available for emergency, ferry, search and test service	8
Airplanes in Major-Overhaul Shops	1
Total	17
Spare Engines Reserved for Emergency at Various Bases	12
Spare Engines Undergoing Complete Overhaul in Shops	4
Total	16
Airplanes: Sikorsky Model S-41, powered with Pratt & Whitney Hornet B, 525-Hp. engines; manufacturer's rated useful load, 6000 lb. (Air mail only, no passengers.)	
Service Hours per Airplane per Year	1,464

Estimated Investment Required

8 Seadromes, in place, at $4,000,000		$32,000,000
3 Land Stations, completely equipped, at $200,000		600,000
17 S-41 Sikorsky Amphibians, at $60,000	$1,020,000	
16 Spare Pratt & Whitney Hornet B Engines, at $7,500 each	120,000	
		1,140,000
Organization and Introductory Costs		325,000
Working Capital		3,051,546
Total		$37,116,546

Estimated Annual Operating Costs

Depreciation and Obsolescence	$2,163,820
Insurance	1,185,545
Maintenance and Upkeep	1,456,680
Additional Indirect and Fixed Costs	975,000
Line Services	2,388,853
Traffic Division	152,500
Miscellaneous and Incidental	832,239
Total	$9,154,637
Unit Cost per Scheduled Mile	$3.512
Unit Cost per Scheduled Hour	386.29

Estimated Annual Operating Revenue

Performance Characteristics of Sikorsky Model S-41 on 400-Mile Service Range:	
Useful Load, lb.	6,000
Total Weight of Crew, Fuel, etc., lb.	2,795
Payload, lb.	3,205
Revenue for One Trip, 3200 lb. of mail at $4 per lb.	$12,800
Daily Revenue (One round trip), 6400 lb. of mail at $4 per lb.	25,600
Annual Revenue (365 round trips), 2,336,000 lb. of mail at $4 per lb.	$9,344,000

between Europe and America that offers any hope of success from the point of view of safety, reliability, frequency of service, capital cost and rates that will be attractive to the public. That we are not alone in this opinion is evident by the endorsement of the foremost European and American authorities in naval architecture, shipbuilding and structural and aeronautic engineering.

Many of the major engineering and manufacturing companies of the United States have been associated with the development and have contributed so importantly and definitely with advice and designs that the construction of the first seadrome can be undertaken immediately with positive assurance of success. My appreciative thanks are due to numerous firms and individuals who collaborated in designing the seadrome and its anchorage gear and worked out methods of fabrication, erection, installation and operation.

Among others, the following have taken an outstanding part in the development program: Henry J. Gielow, Inc., New York City, naval architects; Black & Bigelow, New York City, aeronautic engineers; Belmont Iron Works, Philadelphia, structural engineers; Sun Shipbuilding Co., Chester, Pa.; General Electric Co., Schenectady, N. Y.; John A. Roebling's Sons Co., Trenton, N. J.; The Lidgerwood Co., New York City; Baldt Anchor & Chain Corp., Chester, Pa.; E. I. du Pont de Nemours & Co., Wilmington, Del.; Sperry Gyroscope Co., New York City; the Bureau of Standards, City of Washington; Sikorsky Aviation Corp., Bridgeport, Conn.; Merritt-Chapman & Scott Corp., New York City; and the Marine Office of America, New York City.

The expert personnel of these companies, experienced in designing, constructing and operating some of the most important mechanical developments of the day, have contributed extensively in the working out of the final design and procedure and have in most cases prepared construction-cost estimates on the basis of which their company would contract for the particular part of the project directly in line with their activities.

Internationally known experts of the United States, England, France and Germany have gone on record, many in a public way, endorsing the project and have offered their services and cooperation in working out the many phases of the proposal. As the seadrome has been designed in accordance with the specifications of both Lloyds and the American Bureau of Shipping, marine insurance underwriters have, after thorough investigation, agreed to write marine insurance at reasonable rates, covering the construction, towing out of the anchorage gear and the seadrome and the subsequent operation of the system.

Legal Aspects of the Seadrome

The question of the legal status of the seadrome is interesting and important in that international airways apparently can be operated without

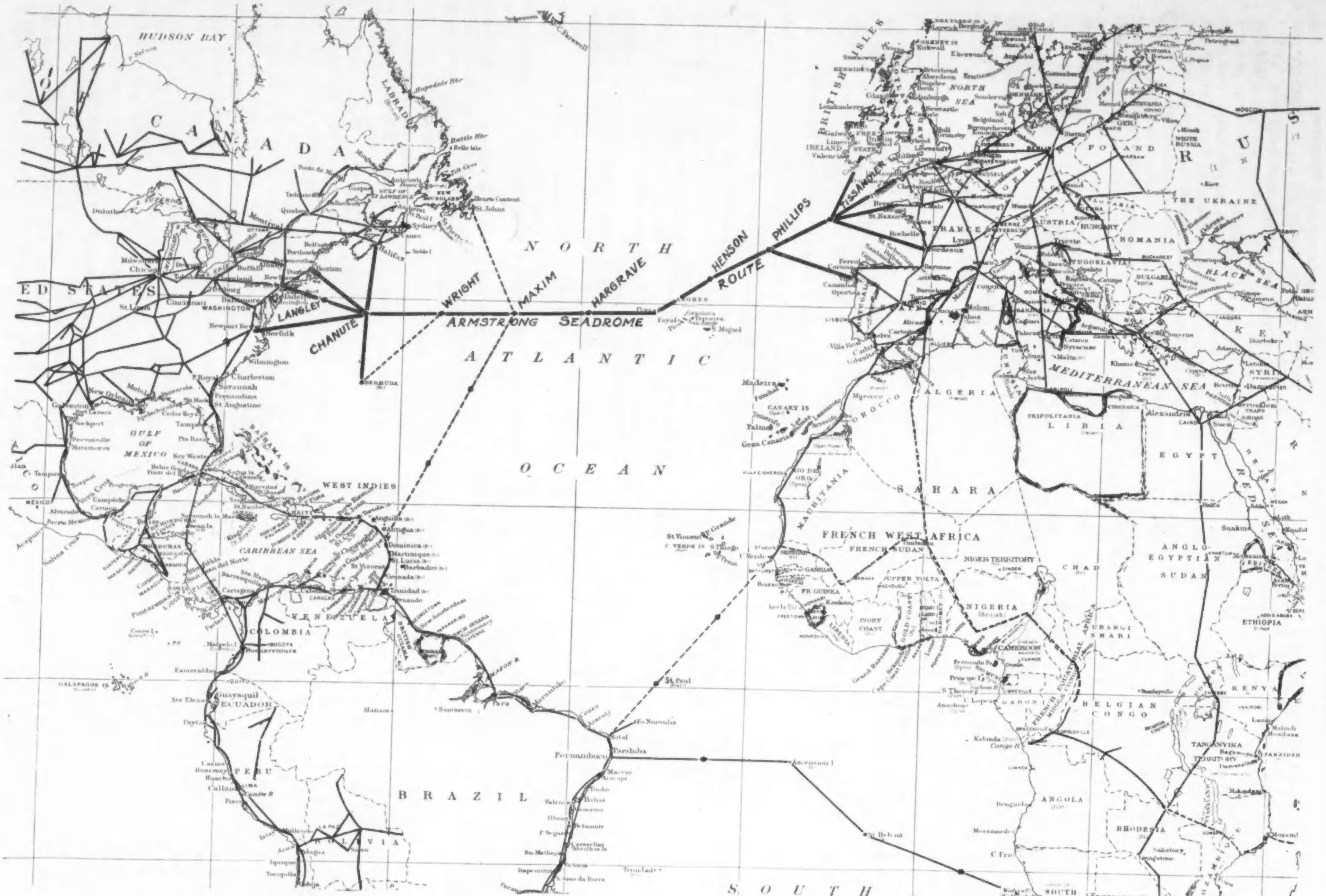


FIG. 10—PROPOSED TRANSATLANTIC SEADROME ROUTES TO CONNECT WITH OVERLAND AIRWAYS OF THE AMERICAS, EUROPE AND AFRICA

international agreements. Terminal seadromes can be used to operate a shuttle service between them and a particular country, each air operation being carried on by aircraft registered under the laws of the particular sovereign power to be connected by that airway.

Ever since the seadrome began to emerge from its early stage of being a fantastic possibility into its present one of being an imminent probability, speculation has been rife on two continents as to its international and legal status. Here was something new, apparently beyond definition by any of the old and accepted legal precedents. Obviously not a ship, because it was not to be used directly for transportation purposes, it was certainly not subject to registration under existing marine laws. Having nothing terrestrial about it, the seadrome is just as obviously not an island, and therefore not subject to national domain. To what nation will it belong, if any? What nation will tax its permanent inhabitants, enforce its laws on the structure, put its courts at the disposal of litigants in the event of any legal trouble, protect it in time of trouble, use it for military aggression in time of war?

These questions have arisen almost wherever the seadrome has been discussed. They have been threshed out by amateurs and professionals alike, and have aroused even more speculation and far greater fears in Europe than on this side of the Atlantic. In England, Germany, Belgium, France, and as far away as South Africa, papers have given space to ponderous arguments, most of which have offered solutions backed by legal precedents, and nearly all have demanded that an international conference be held in the future to discuss the seadrome.

Most of the commentators, however, seem to feel that the seadrome problem cannot be dismissed by any one nation's simple refusal to permit the placing of one of the structures near its coastline. They remember that the seadrome invention holds almost unlimited possibilities for speeding up the commerce of the world and that to stand in the way of the world's economic progress, even on the grounds of the security of any nation is dangerous. Most of them agree with the French statesman, Senator Lemery, who stated:

> It is of the greatest importance to the world in general that this new form of progress should be made the subject of international agreement and not left alone until seadromes become a formidable weapon in the hands of one country sufficiently wealthy and enterprising to take the initiative.

That the Europeans are taking the imminent legal complications regarding the seadrome far more seriously than we Americans are is also shown by the fact that the congress on aviation law held at Budapest in October, 1930, has already busied itself with the problem. This conference decided that sovereignty over the structures, as far as actual operation was concerned, should be in the hands of the nation whose citizens built them; that the placing of the seadromes on the high seas should be formally called to the attention of the nations of the world; and that any litigation arising out of them should be referred to the League of Nations.

Private Property, Subject to American Protection

In effect, this decision agrees closely with the results of the investigation made by Charles E. Asnis, member of the Philadelphia bar, formerly lecturer in political science at the University of Pennsylvania. Mr. Asnis is of the opinion that, while the international status of the seadrome should at some time be clearly defined by specific international agreement, it will be time enough to "consider conventional regulations when the activities and services of the drome will have been studied in the light of experience and of scientific and commercial contributions." He urges caution, moreover, in the matter of taking any premature action, on the ground that "untoward interference would tend to retard its useful functions whose services in the interests of humanity would link the oceanic nations with a speed and efficiency as if they were terrestrial neighbors." For the present he sees no legal obstacle whatever in the way of the construction of the seadromes and finds it "difficult to see that precedent consent for the operation of the drome is to be required of a concert of powers such as the League of Nations."

As to the definition of the seadrome, after pointing out that it is obviously neither ship nor island, Mr. Asnis says:

> It is property in the strictest sense of the word; private property, every bolt and beam of which were

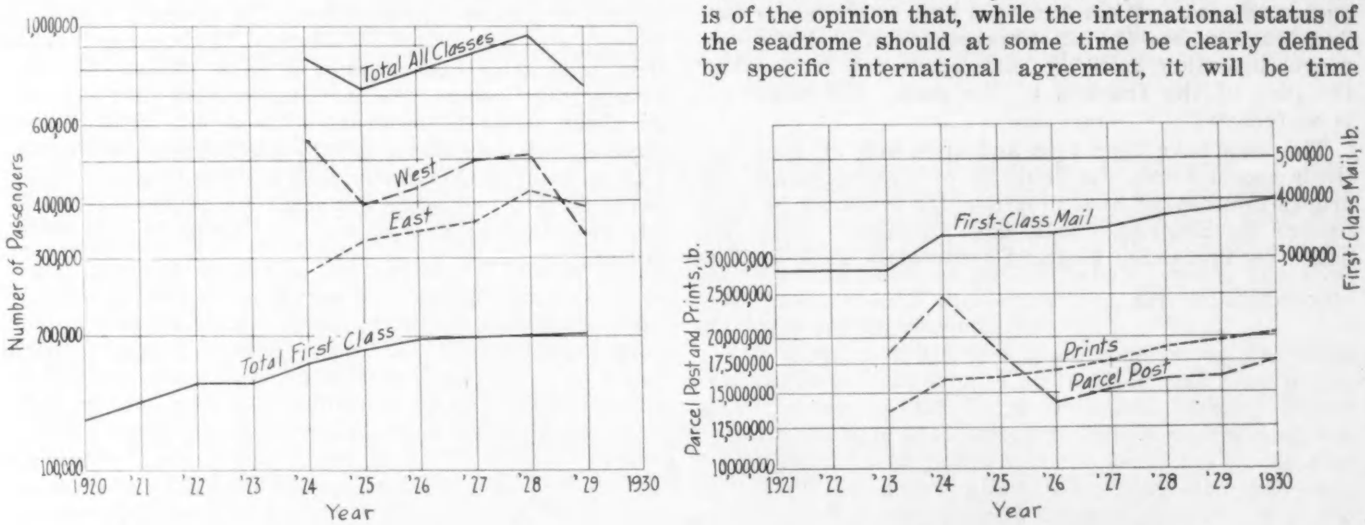


FIG. 11—VOLUME OF TRANSATLANTIC-STEAMSHIP PASSENGER TRAFFIC AND EAST-BOUND MAIL FOR THE LAST 10 AND 9 YEARS RESPECTIVELY

> fashioned by its owners; and, as owners of private property, the dominion over it is as extensive and as inclusive as dominion over property on land. . . . Having the rights of property and dominion thereover, the administration of the affairs of the drome by the owners would be relaxed by convention or voluntary renunciation only.

Regarding national sovereignty of any kind, he says:

> Granted a peaceful and serviceable function, ministering to the beneficent needs of man in advanced methods, by flight, of communication and transportation, the imposition of the will of any single power on the impartial operation of the drome would have no moral justification by law.

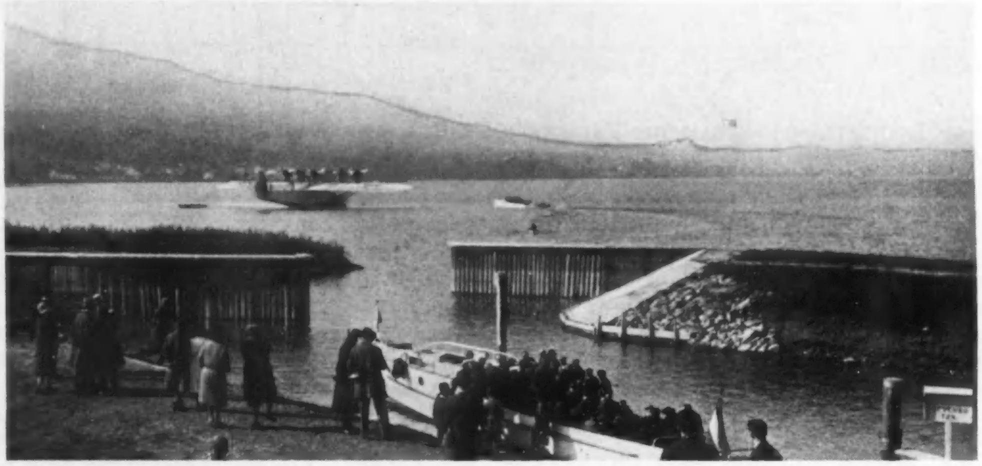
In other words, the seadromes would be subject to American protection in case of need, just as any American private property, in the Sahara Desert or elsewhere, would be subject to that protection. But neither State nor Federal American laws nor those of any other nation would be applicable on the structures, as long as their operations are "free from practices which would shock the conscience of mankind."

On the question of whether Americans or any other nationals have the right, established by precedent, to anchor the dromes, Mr. Asnis not only emphatically says "yes," but makes the startling assertion that the seadrome invention pulls the very props out from under the idea of the freedom of the seas. His argument is as follows:

The seas have been free and open only in comparatively recent times, the principle of occupation and appropriation having been practised for centuries by such nations as England, Spain and Portugal. After the battle of Trafalgar, England voluntarily gave up this principle, and the idea of the open seas became the universal practice of nations. However, most authorities agree that the seas were admitted to be free only because they were incapable of occupation or effective defense, one man stating that, "The true foundation of the rule that the open sea is not subject of sovereignty is the fact that it is not capable of occupation."

Now, for the first time in history, a human invention makes effective and permanent occupation of the high seas possible. Just what consequences this will have on the principle of the freedom of the seas remains to be seen. Mr. Asnis is concerned only with the status of the seadrome, and he finds that, while no precedent exists for the idea of permanent residences on the ocean, plenty of precedent allows these residences to be placed and owned there.

The seadromes will occupy their positions by right of preeminent domain, but it must be remembered that they no more occupy the shifting waters on the surface of the ocean than a skyscraper occupies the shifting winds that blow around it. The real foundation of the seadrome, the spot to which its builders can perfectly well make proprietary claims, is on the sea bottom—on the anchorage site. This spot is the "real estate" from which the structures project upward, just as buildings project upward from the ground, which is amenable to ownership. Therefore, it becomes obvious that, no matter how alarmed foreign nations or politicians may become, the Armstrong Seadrome Co. can go ahead with its program without any special permission from anybody and without fear of interference. That an international conference of some form will eventually be held to discuss the seadrome seems inevitable, but we intend neither to wait for it nor to take steps to bring it about.



Combustion and Design Problems of Light High-Speed Diesel Engines

By E. F. Ruehl[1]

Annual Meeting Paper

MORE attention must be paid to light-weight design and to flexible combustion control if the Diesel engine is to become a serious competitor of the gasoline engine. The relative merits of existing types of combustion-chamber and injection systems used in present commercial four-cycle engines are discussed, and it is shown that the single-turbulence-chamber type offers the most promising means to high mean effective pressures at low fuel consumption. Stock high-pressure fuel-pumps and injection-valves, produced in volume by specialists, will have a great influence on the production of high-speed Diesel engines. The interrelation of combustion and injection processes in controlled-turbulence combustion-chambers is explained, and design details and test results are given of the practical application of single-chamber principles and of a stock injection system to flexible combustion control in a recently developed high-speed four-cycle engine.

Factors limiting mean effective pressure and piston speeds are discussed, as are also the mechanical problems of design, cooling and lubrication of vital parts. In comparing Diesel-engine with gasoline-engine weights, due allowance is made for the difference in maximum gas pressures.

The illustrations show examples of various combustion-chamber designs and design details and photographs of DeLaVergne high-speed engines.

EFFORTS being made by manufacturers of both Diesel engines and gasoline engines to produce Diesel engines that equal gasoline engines in weight, size, speed, power, performance and reliability reflect recognition of the inherent superiority of Diesel engines in fuel consumption and torque characteristics with variable load and speed, in purity of exhaust, cold-starting qualities and fire risk. These advantages must be combined with the established qualities and lower price of the gasoline engine before the Diesel engine will dominate the fields such as those of motorboats, rail-cars, small locomotives, motor-trucks, motor-coaches, tractors, excavators and portable generating, compressor, pumping and oil-drilling sets, in which gasoline engines now are supreme.

Correct distribution and selection of the material, increasing the piston speed, and increasing the mean effective pressure are the means by which the goal of light-weight Diesel engines can be attained. I shall discuss these problems in this paper and present recent developments and accumulated experiences. I shall deal with four-cycle solid-injection engines only; because air injection plays no part in small powers, and two-cycle engines, with rare exceptions, are not sufficiently developed for high speed.

The Diesel engines that I am considering are those that range in bore from 4 up to 10 in. and have piston speeds of about 1200 ft. per min. and higher. Tables 1, 2 and 3 have been prepared for comparison of the weight, speed and power of representative commercial Diesel and gasoline engines. It will be seen that some of the small Diesel engines compare favorably with the gasoline engine as to specific weight and output. The majority of the Diesel engines are, mainly because of tradition, unnecessarily much heavier than the gasoline engines, a fact which has retarded their application to marine and transportation service.

Closer attention to light-weight design is demanded

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TABLE 1—HEAVY-DUTY HIGH-SPEED ENGINES OF LESS THAN 5-IN. BORE

	Diesel Engines							Gasoline Engines		
	Single Combustion-Chambers and Individual Fuel-Pumps				Antechambers		Acro System			
	Cummins	Linke-Hoffman	M.A.N.	Packard	Mercedes-Benz	Deutz	Saurer	Buda	Wauke-sha	M.A.N.
Number of Cylinders	6	4	6	9	6	6	6	4	6	6
Bore	4½	4½	4.7	4 13/16	4.13	4.53	4.33	3¾	4⅛	4.32
Stroke	6	6½	7.1	6	6½	6.7	5.9	5⅛	4¾	6.5
Revolutions per Minute	1,000	1,200	1,000	1,950	1,300	1,250	1,600	1,800	1,600	1,800
Brake Horsepower	60	50	68	225	70	80	80	36.5	68	100
Total Cylinder Displacement, cu. in.	572.5	410	738	982	523	646	520	226	381	570
Engine Weight, lb.	2,200	1,100	1,980	510	1,600	1,650	....	660	890	1,280
Mean Effective Pressure, lb. per sq. in.	83	80	71	92.7	81.6	78.5	74.6	71	88.5	77.5
Piston Speed, ft. per min.	1,000	1,300	1,185	1,950	1,410	1,394	1,575	1,540	1,270	1,950
Weight: Displacement, lb. per cu. in.	3.84	2.7	2.68	0.52	3.06	2.53	....	2.92	2.34	2.25
Specific Weight, lb. per b.hp.	36.6	22.0	29.2	2.27	22.9	20.6	....	18.1	13.1	12.8
Specific Output, b.hp. per cu. ft.	182	212	159	398	230	214	267	279	308	302
Brake-Horsepower per Cylinder	10	12.5	11.3	25	11.7	13.3	13.3	9.1	11.3	16.7
Fuel Consumption at Rated Mean Effective Pressure, lb. per b.hp-hr.	....	0.42	0.43	0.46	0.46	0.46	0.49	....	....	....

TABLE 2—HEAVY-DUTY HIGH-SPEED ENGINES OF 5-IN. AND UP TO 7-IN. BORE

	Diesel Engines										Gasoline Engines			
	Single Combustion-Chambers and Individual Fuel-Pumps						Antechambers							
	Treiber	Krupp	Treiber	Buda	Buda	Cummins	Hill	Koerting	Ober-haensli	Hill	Sterling	Buffalo	Waukesha	Waukesha
Number of Cylinders	6	6	6	6	6	6	6	6	4	6	6	6	4	4
Bore	5	5.3	6	6	6½	6¾	5	5.1	5.12	6	5¾	5⅞	5¾	6¾
Stroke	7	7.85	8	8	8¾	9	7	7.1	7.48	10	6¾	7	8	8
Revolutions per Minute	1,200	1,000	1,000	1,000	1,000	800	1,000	1,200	1,250	800	1,000	1,500	950	950
Brake Horsepower	100	100	150	138	180	170	75	90	60	120	150	160	80	120
Total Cylinder Displacement, cu. in.	825	1,040	1,360	1,360	1,742	1,930	825	880	615	1,696	1,050	1,138	830	1,145
Engine Weight, lb.	2,200	1,760	....	4,550	5,425	5,000	3,920	3,300	....	7,500	2,750	3,400	5,025	5,125
Mean Effective Pressure, lb. per sq. in.	80.0	74.5	87.5	80.6	81.85	87.5	72	67.5	71.3	70	113	70	80.5	87
Piston Speed, ft. per min.	1,400	1,305	1,333	1,333	1,458	1,200	1,166	1,420	1,560	1,333	1,125	1,750	1,270	1,270
Weight: Displacement, lb. per cu. in.	2.67	1.69	....	3.33	3.12	2.59	4.75	3.75	....	4.43	2.62	2.98	6.05	4.47
Specific Weight, lb. per b.hp.	22.0	17.6	....	33.0	30.3	29.4	52.5	36.7	....	58.6	18.3	19.4	62.8	42.6
Specific Output, b.hp. per cu. ft.	210	166	191	174	179	152	157	177	194	122	247	271	166	181
Brake-Horsepower per Cylinder	16.7	16.7	25	23	30	28.3	12.5	15	17.2	20	25	26.7	20	30
Fuel Consumption at Rated Mean Effective Pressure, lb. per b.hp.-hr.	0.43	0.45	0.43	0.435	0.435	....	0.46	....	0.46	0.46	....	....	....	....

of the Diesel engineer, and the weight reduction must be accomplished without expensive refinements. Our endeavors to bring the structural weight of the Diesel engine down to gasoline-engine figures are handicapped by the higher maximum gas pressures that must be sustained by the frame, cylinder-heads, pistons, connecting-rods and crankshaft.

Maximum combustion pressures higher than 700 to 750 lb. per sq. in., which are about 60 per cent higher than in modern gasoline engines, will not be necessary for high mean effective pressure and low fuel consumption. A 5-per-cent increase in crankshaft diameter, which means about a 10-per-cent increase in weight, will sufficiently compensate for the higher loads. The connecting-rod will have to weigh about 20 per cent more. The weight difference for the frame and cylinder-heads need not be more than about 30 per cent, for the same material; because gasoline-engine castings are usually cast much heavier than necessary, for foundry reasons. The weight of the other engine parts can be the same in both cases, inasmuch as the Diesel engine is inherently as simple as or simpler than the gasoline engine.

A total weight differential of 15 to 25 per cent therefore seems to be sufficient to meet the effects of higher gas pressures. These figures are confirmed in practice by some of the Diesel-engine types, as indicated by the specific weights in Tables 1 to 3. Weight saving through the use of aluminum alloys or thin steel castings instead of nickel cast-iron is no longer a difficult problem, but purely a question of economy. The application of these materials in Diesel engines for transportation purposes, where weight reduction of the engine results in higher payload, is economically sound.

Reducing the engine weight per horsepower by increasing the rotative speed involves problems of reducing and balancing inertia forces, of bearing design, wear, cooling and lubrication which will be discussed in detail later in the paper. The real limit of power increase through an increase in speed is set by the natural breathing capacity, which depends on volumetric efficiency. The volumetric losses increase rapidly beyond a certain piston speed, so that the charge of combustion air decreases in inverse proportion to the engine speed, with the result that the torque drops off quickly. This limitation can be overcome by supercharging, which is at present not commercially feasible for the purposes here considered.

TABLE 3—HEAVY-DUTY HIGH-SPEED ENGINES OF 7 TO 10-IN. BORE

	Diesel Engines												Gasoline Engines		
	Single Combustion-Chambers and Individual Fuel-Pumps							Single Combustion-Chambers and Common-Rail System							
	Ricardo	Foos	De La Vergne	Westinghouse	McIntosh-Seymour	Cummins	Ingersoll-Rand	Atlas-Imperial	Bessemer	Winton	Speedway	Superior	Sterling	Winton	Brill
Number of Cylinders	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Bore	7½	8½	9	9	9½	10	10	7	7½	8	8½	8½	8	8	8¾
Stroke	12	11	11	12	10½	12	12	8½	10½	10	11	11	9	10	10½
Revolutions per Minute	900	700	750	900	800	800	550	650	650	750	700	600	900	900	950
Brake Horsepower	300	230	300	400	360	500	300	120	200	250	300	210	300	300	400
Total Cylinder Displacement, cu. in.	3,180	3,750	4,180	4,575	4,460	5,655	5,655	1,962	2,782	3,020	3,750	3,750	2,720	3,020	3,780
Engine Weight, lb.	11,000	10,500	10,000	12,900	14,400	14,500	19,000	6,600	8,200	7,400	7,600	....	5,670	7,400	8,000
Mean Effective Pressure, lb. per sq. in.	83	70	75.5	77	80	87.6	76.4	74.5	87.6	87.5	90.5	73.8	97.5	88	88
Piston Speed, ft. per min.	1,800	1,280	1,375	1,800	1,400	1,600	1,100	921	1,138	1,250	1,285	1,100	1,350	1,500	1,660
Weight: Displacement, lb. per cu. in.	3.46	2.80	2.39	2.82	3.23	2.56	3.36	3.36	2.95	2.46	2.05	....	2.08	2.45	2.11
Specific Weight, lb. per b.hp.	36.7	45.5	33.3	32.3	40.0	29	63.3	55	41	29.6	25.3	....	18.9	24.7	20.0
Specific Output, b.hp. per cu. ft.	163	106	124	151	140	153	92	106	124.5	143	138	97	190	173	183
Brake-Horsepower per Cylinder	50	38.3	50	66.7	60	83.3	50	20	33.3	41.7	50	35	50	50	66.7
Fuel Consumption at Rated Mean Effective Pressure, lb. per b.hp-hr.	0.38	....	0.39	0.40	....	....	0.44	0.42	0.43	0.44	0.43	0.45	....	....	....

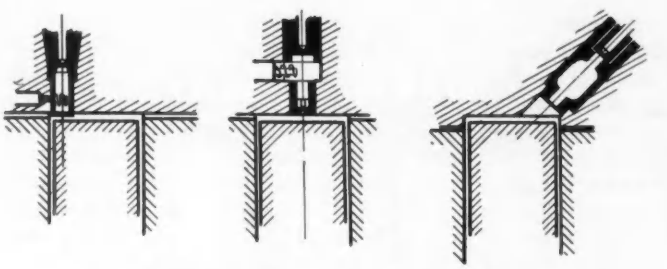

FIG. 1—ANTECHAMBER INJECTION ARRANGEMENTS
Combustion-Chambers Shown Are of the Following Engines, the Bore of the Engine in Inches Being Indicated: Left, Deutz, 4½; Center, Mercedes-Benz, 4.13; Right, Hill, 3½ and 5

Combustion control is the essential problem which influences the whole design. The solution depends on the selection of the type and form of the combustion-chamber and on the fuel-injection system.

Combustion-Chamber Designs

Combustion-chamber developments have reached a point where it is no longer necessary to cast about for fundamentally new forms, as existing types offer a diversified and rich selection. The questions to be considered in deciding upon the type and shape to be used are: first, which designs make possible good combustion at variable loads and speeds and high mean effective pressure and, second, which design attains its ends and purposes in the simplest manner?

Suitable combustion-chambers fall into three groups. Examples of the first group, in which the fuel is injected into a small precombustion or antechamber at moderate pressures, are shown in Fig. 1. A part of the fuel partially burns in the precombustion-chamber, resulting in a pressure rise. This projects the remaining fuel, highly heated air and products of combustion through one or several communicating holes into the main chamber, where further combustion takes place.

A second group is represented by Fig. 2, showing the Acro system, in which the combustion air is compressed into an air-storage chamber placed either in the piston or in the cylinder-head. This chamber communicates with the clearance space between the piston and the cylinder-head through a narrow funnel into which the fuel is injected at moderately low pressure. The air-chamber supplies air to the burning fuel, making the combustion process similar to that in a blow-torch. The Acro chamber shares with the antechamber the advantage of low fuel-pump pressure and coarse jets, and the drawbacks of hard starting and reduced thermal efficiency.

Single Chambers Are Simple and Efficient

The third group comprises single chambers into which fuel is injected at high pressures either through one central injection valve with a single or multi-hole nozzle or through one or two valves from the side. Examples of this group are shown in Figs. 3 to 5.

Without going too far into a detailed analysis of the relative merits of the different designs, it seems safe to say that the single-chamber type offers the simplest and most efficient solution to combustion and heat-control problems under variable conditions. This type provides for the highest mean effective pressure and can be applied equally well to large and small engines, while the first and second types are applicable to small engines only. Single-chamber engines are easier than others to start when cold.

The antechamber type has a much larger cooled surface, which results in much greater heat losses during compression and combustion. The flow of heat to the cooling-water is further increased by concentration of heat in the small communicating holes, due to the high velocity and temperature of the gas mixture that is projected into the main chamber. These conditions restrict to a large extent the combustion efficiency and the mean effective pressure that are attainable, especially in large cylinders. The mean effective pressure of an antechamber engine is also curtailed by a lesser degree of scavenging and by lower volumetric efficiency, and it requires a more complicated and heavier cylinder-head. To facilitate starting from cold, a higher compression-ratio and in most cases electric heating coils must be resorted to, which add complications.

Among the advantages of the antechamber engine

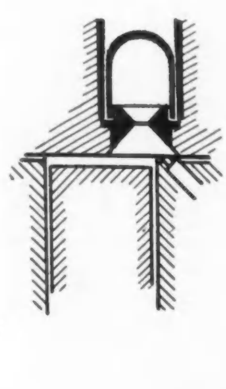

FIG. 2—ACRO SYSTEM
Saurer Engine, 4.33-In. Bore

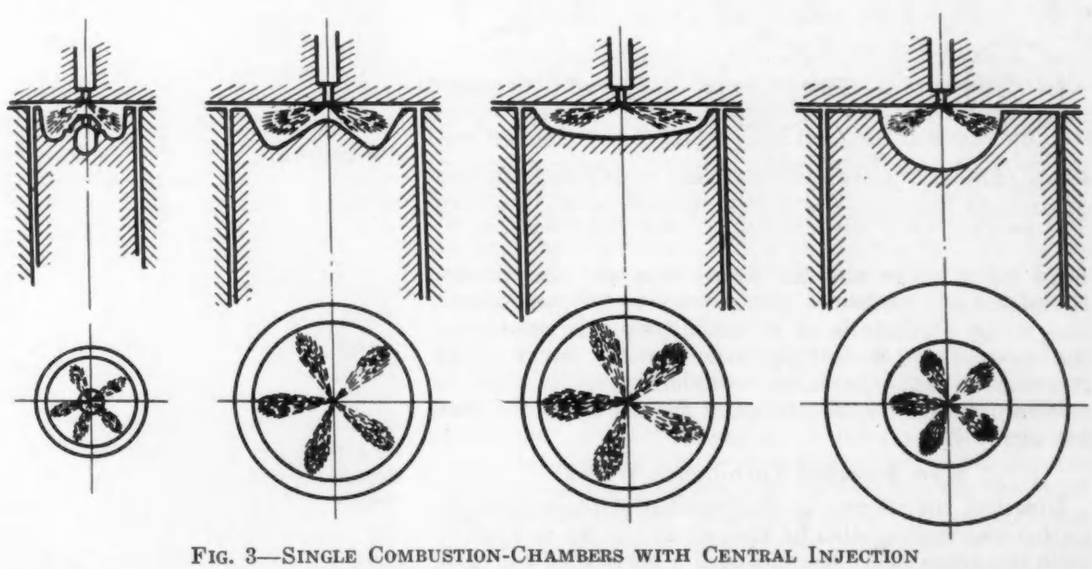

FIG. 3—SINGLE COMBUSTION-CHAMBERS WITH CENTRAL INJECTION
The Sketch at the Left Represents Cummins Engines of 4½ and 6¾-In. Bore; the Left-Center Sketch Represents Winton 8 and 8½-In., Westinghouse 8¼ and 9-In. and Bessemer 7½ and 9-In.-Bore Engines; the Right-Center Sketch Represents M.A.N. 8.7 and 10.2-In., Treiber 8½-In., Superior 8½-In. and Foos 8½-In.-Bore Engines, and the Sketch at the Right Represents a McIntosh Engine Having 9½-In. Bore

are that it probably is less sensitive to the use of the heavier grades of fuel and that it does not require such high injection pressures, which latter are beneficial to the life of the fuel-pump. The advantage of ability to handle heavier oils becomes less with increasing adoption of specification fuels.

Principles of Single-Chamber Design

The examples of single-chamber design given in Figs. 3 to 5 show great differences in regard to shape. In general, the form of the combustion-chamber should be adapted to the direction and shape of the spray jets, the air-intake valves and their ports should be arranged so as to promote directed air turbulence, the piston should cause additional air whirl near top dead-center, and the whole mass of rotating and whirling air should be penetrated by the fuel jets.

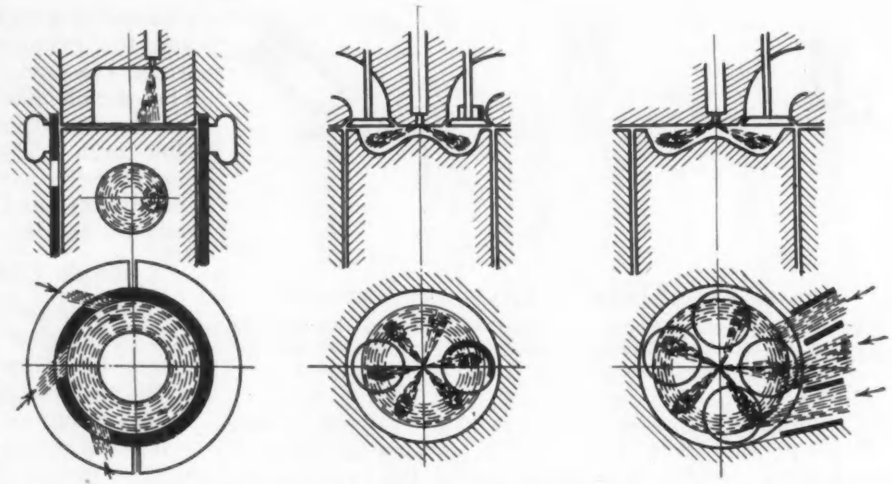

FIG. 5—SINGLE COMBUSTION-CHAMBERS WITH DIRECTED TURBULENCE AND CENTRAL INJECTION

The Sketch at the Left Represents Ricardo Engines of 5½ and 7½-In. Bore; the Central Sketch Is of the Hesselman Engine; and the Sketch at the Right Is of the DeLaVergne 9-In.-Bore Engine

Attention will be focused in what follows on single-chamber designs in which combustion is aided by directed air turbulence as the most promising means to high mean effective pressure with low fuel consumption over wide ranges of load and speed. If fine spray atomization by high-pressure injection alone were to be depended upon to accomplish this end, the nozzle holes would have to be very small and numerous and the pump pressures for the larger cylinders exceedingly high, which would be a great disadvantage.

Uncontrolled turbulence is developed in any of the single chambers shown in Fig. 3 to 5 by the rapid displacement of the air entrapped between the outer portion of the piston top and the bottom of the cylinder-head. The wider the flat piston rim and the smaller the piston end clearance, the greater is this turbulence. The width of the rim of a dished piston is limited by the necessity of providing room for the spray. The rim can be wide in large cylinders, but it must be narrow in small engines to avoid the necessity for very fine spray holes.

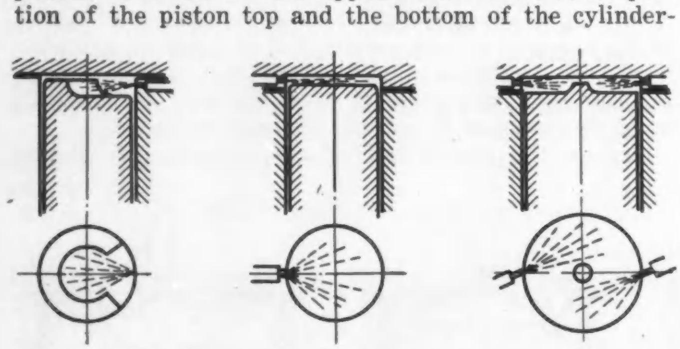

FIG. 4—SINGLE COMBUSTION-CHAMBERS WITH SIDE INJECTION

The Engines Represented, with Their Bores in Inches, Are: Left, Packard, 4.81; Center, M.A.N., 4.7, and Right, Buda, 6

How Directed Turbulence Works

Directed turbulence in conjunction with central injection was first applied by Hesselman, as far as I know, some ten years ago. He shrouded a portion of the inlet valve as shown in Fig. 5 so that the air flows into the cylinder tangentially and rotates, after being compressed, at such speed that it moves from one fuel jet to the next during the injection period. Ricardo employed the same principle in his high-speed sleeve-valve engines, illustrated diagrammatically in Fig. 5. He reports results of tests on a single-cylinder $5\frac{1}{2}$ x 7-in. engine which are most interesting. The indicated mean effective pressure at the normal speed of 1300 r.p.m. was 112 lb. per sq. in., with a fuel consumption of 0.29 lb. per i.hp., and 122 lb. per sq. in. indicated mean effective pressure with a fuel consumption of 0.285 lb. per i.hp. at 2200 r.p.m. A fuel consumption of 0.38 lb. per b.hp. is guaranteed with the $7\frac{1}{2}$ x 12-in. Ricardo commercial engines at 900 r.p.m.

Ricardo's excellent results are obtained with a single solid fuel-jet from one large open nozzle of 1/32-in. diameter, placed vertically, near the high cylindrical wall of the combustion-chamber, as shown in Fig. 5. Tangential ports in the sleeve valve direct the air into the cylinder in a circular current, the angular speed of which is approximately doubled when the air stream is transferred, without losing peripheral speed, into the compression space having a diameter about one-half that of the cylinder. Uncontrolled turbulence is superimposed upon the directed rotational swirl near top dead-center by the displacement action of the piston. Ricardo found through experiments that the best results are obtainable when the entering air is so directed that it makes one revolution within the combustion-chamber in a crank angle of from 30 to 36 deg., which is identical with the injection period at full load.

The attractive feature of Ricardo's high-turbulence chamber is the simple spray-nozzle having a hole of unusually large diameter. This feature eliminates the danger of choked nozzles and also allows low fuel-pump pressures. The last is very desirable, as high pressures increase maintenance costs of the fuel-injection parts. These advantages are, however, heavily penalized by the necessity for a sleeve-valve construction, which leads to expensive mechanical complications.

The shrouded inlet valve looks to be much simpler than the sleeve-valve construction, but the shroud masks a considerable part of the valve circumference and disturbs the streamline flow, with the result that the volumetric efficiency is decreased, which is a big handicap to a high-speed engine.

Directed turbulence effect was sought in the new DeLaVergne high-speed engine by the arrangement of simple dual inlet-valves represented diagrammatically in Fig. 5. The valves are so placed and the inlet ports so shaped that the air is drawn in spirally and induces a rotational motion on the vortex-shaped piston, and the circular motion of the air is intensified during the compression stroke. The fuel is injected through the five-hole nozzle of a centrally located Bosch-type spray valve. The jets are directed fairly close to the piston-head but do no touch it, so that the air immediately below the flat cylinder-head expands through the burning fuel jets during the down stroke of the piston.

The rotational speed of the air in the cylinder of this engine has not been measured, but the high mean effective pressure and good fuel-consumption results obtained with moderate injection pressures allow us to assume that well-directed turbulence of the air charge actually takes place at the desired rotational speed, which increases and decreases approximately in direct proportion to the engine speed. The results of previous tests on a two-cylinder 8½ x 12-in. experimental engine, shown in Fig. 6, are represented in Fig. 7, from which it is seen that a fuel consumption of 0.41 lb. per b.hp. was obtained at 600 r.p.m. on Ontario crude-oil. The consumption was 0.40 lb. per b.hp. at the normal rated mean effective pressure of 80 lb. per sq. in. during long periods of running on ordinary Diesel fuel. This experimental engine had a combustion-chamber similar to that of the new engine, as shown diagrammatically in Fig. 5, but the arrangement of the inlet ports was not quite as good. The new engine has a still lower fuel consumption, because of the better-controlled turbulence.

The Combustion Process

Combustion in directed-turbulence chambers takes about the following course: The fuel enters shortly before dead-center and penetrates the compressed whirlwind of hot air, the finer atomized particles on the outer layers of the fuel jets become heated to the ignition point, and small initial flames are formed around the fuel jets. This first phase of combustion occupies a comparatively long time, as indicated in Fig. 8, and is called the ignition delay or time lag. The ignition delay in seconds is practically constant and independent of the engine speed, and there can be no noticeable pressure rise above the compression line during this phase. As the flat rim of the piston approaches the cylinder-head, it displaces the outer ring of air and sets up vigorous turbulence, so that the fuel that has already entered is thoroughly mixed with oxygen and burns in a very short time. A rapid rise in pressure and temperature occurs during this second phase, at almost constant volume.

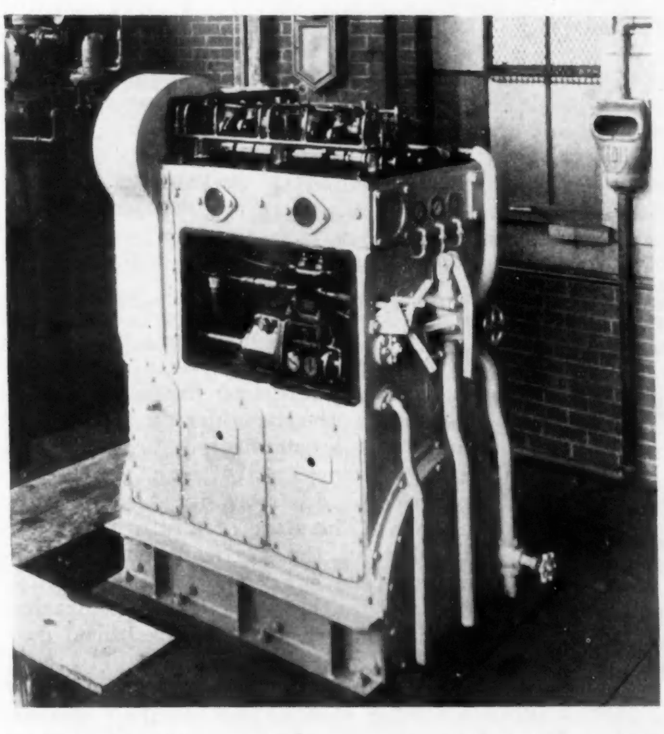

FIG. 6—DELAVERGNE EXPERIMENTAL 8½ X 12-IN. TWO-CYLINDER ENGINE

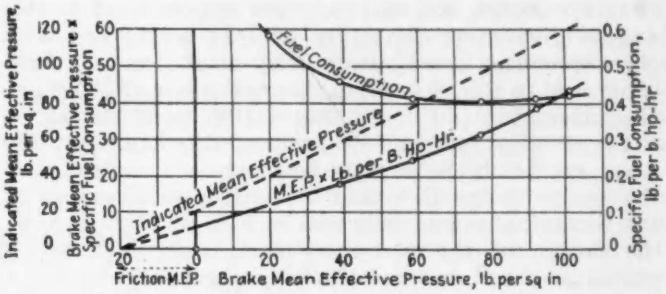

FIG. 7—TEST CURVES OF DELAVERGNE 8½ X 12-IN. TWO-CYLINDER EXPERIMENTAL ENGINE

Ontario Crude Oil Was Used as Fuel, the Engine Running at 600 R.P.M. Examples of the Use of Curves Such as This Are Given in a Paper by Otto Nonnenbruch[2]

[2] See *Transactions of the American Society of Mechanical Engineers*, 1929, paper OGP-51-3.

The mixture in the combustion-chamber is now so hot that further fuel ignites as it enters, the fuel droplets burning from the surface of the main jets as they meet the fresh particles of air that are being supplied continuously by the rotating stream of air. At the same time the products of combustion are swept away from the burning jets by the air-stream. This constitutes the third phase of the combustion.

Ignition Lag No Barrier to High Speed

Ignition lag is in the order of 0.001 to 0.002 sec. and depends on: (*a*) the ignition point of the fuel; (*b*) the temperature of the compressed air, which is a function of the compression ratio and of the suction air temperature; and (*c*) the distribution and fineness of atomization of the fuel spray, which is determined by the injection pressure and nozzle characteristics. The ignition lag decreases during the injection. The ignition timing can be advanced to compensate for the ignition lag as the speed increases; therefore, the maximum engine-speed is not limited by ignition lag.

The rapid pressure rise depends on: (*a*) the vigor of uncontrolled turbulence, (*b*) the timing and rate of fuel injection, (*c*) the initial pressure and temperature conditions in the combustion-chamber. The pressure rises but slightly or is maintained constant, according to the shape of the fuel-pump cam, during the third phase of combustion. The rapidity of the pressure rise during the second phase is also influenced by the fuel cam.

The actual interrelation between injection and combustion phases of a 9 x 11-in. high-speed engine can be studied by means of Figs. 8, 9 and 10. The combustion-

chamber design and fuel-injection system used in this engine give great flexibility of load and speed with clear exhaust. The ignition delay marked on the indicator card in Fig. 8 as 8 deg. in crank angle at 750 r.p.m. is equivalent to $(60 \times 8)/(750 \times 360) = 0.0018$ sec.

Fig. 8 is an indicator diagram of this engine at 750 r.p.m. on which the various pressures are marked, also the events in the cycle and the phases as described in the foregoing and as indicated in Fig. 9. Fig. 9 shows the design of the fuel-pump cam, and illustrates a graphical determination of the plunger velocity by a parallelogram of velocities, which is applicable at any point of the lift curve of the cam. The rotational velocity of the point on the roller-center curve in feet per second, which is used as one side of the parallelogram, is found from the distance of this point from the cam center and the rotational speed of the camshaft. Fig. 10 is a diagram of the plunger velocity and injection pressure at an engine speed of 750 r.p.m., based on Fig. 11, with the upper dead-center of the engine and events of the cycle indicated to correspond with Figs. 8 and 9.

Selection of Injection System and Process

Development of combustion-chambers for high-speed engines has been limited to a large extent by the problem of producing reliable means for the accurate metering, timing, injecting and distributing of small quantities of fuel during a very short time-interval. The antechamber, which may be regarded as a temporary solution, was devised principally because it does not require high fuel-injection pressures and needs no small holes in the injection nozzle. Antechambers are losing their importance since the difficulties in filtering the smallest particles of grit from fuel and manufacturing delicate high-pressure injection parts for small engines have now definitely been overcome by the application of modern precision methods and the use of nitrided steels. Reference to the Tables 1 and 2 indicates that antechamber engines cannot compete with single-chamber engines in regard to specific weight and fuel consumption. With directed turbulence as an effective aid in mixing the charge in single chambers, only moderate injection pressures are needed. This tends to increase the life of the injection parts and the reliability of the engine.

There are two systems that fulfill the requirement of quickly injecting small quantities of fuel at high pressure: (a) the common rail and (b) the individual cam-driven fuel-pump for each cylinder. Both systems have been applied successfully, but there are differences in performance with variable load and speed conditions which should determine the selection.

Equal distribution of fuel over all cylinders at variable loads and speeds is difficult to maintain with the common-rail system, on account of possible inaccuracies, uneven wear, deflection and heat expansion of its many moving or adjustable parts such as rocker arms, links, push-rods and regulating wedges, which are all involved in the mechanical opening of the fuel-spray valves. One or more cylinders may misfire at light loads, even when the adjustment is such that the fuel distribution is perfectly even at full load. This is a serious handicap, particularly in small high-speed engines requiring extreme flexibility and smokeless exhaust. For this and other reasons, the trend is decidedly toward the individual-pump system.

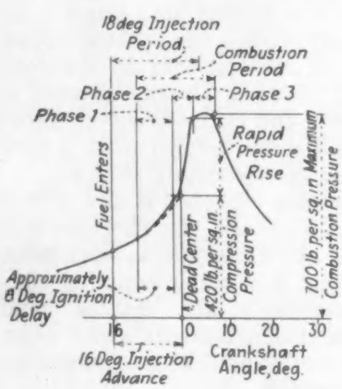

FIG. 8 — COMBUSTION PHASES SHOWN ON INDICATOR DIAGRAM

Based on Actual Diagram of 9 x 11-In. Engine at 750 R.P.M.

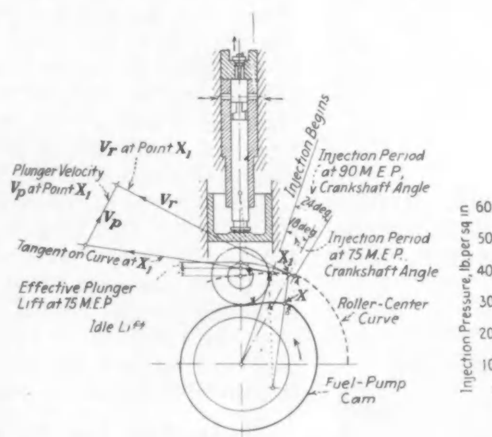

FIG. 9—FUEL-PUMP CAM DESIGN FOR 9 X 11-IN. DELAVERGNE ENGINE

The Pump Used Is a Bosch Having 0.473-In. Bore and 0.594-In. Stroke. The Method Is Indicated for Finding the Plunger Velocity at Any Point by a Parallelogram

The notation in Figs. 9 and 10 is as follows:

A = specific gravity of fuel, referred to water
C = coefficient of contraction
D = diameter of fuel-pump plunger, in.
d = diameter of injection-nozzle holes, in.
n = number of nozzle holes
P_i = injection pressure
P_p = pump pressure = P_i plus 650, representing pipe friction and gas pressure, lb. per sq. in.

Angles given refer to rotation of crankshaft

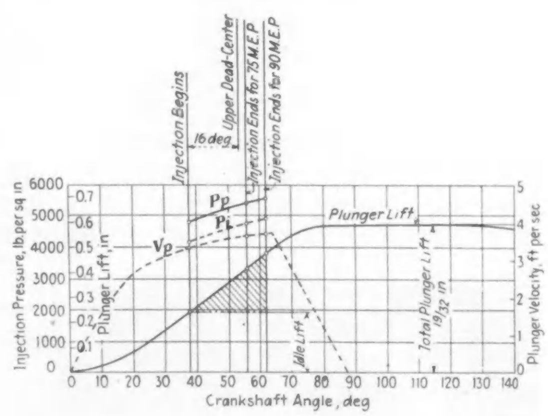

FIG. 10—DIAGRAM OF PLUNGER VELOCITY AND INJECTION PRESSURE

This Diagram Is Based on Fig. 9
The Injection Pressure Is Found by the Following Formula:

$$P_i = 0.00678\ A \times V_p^2\ [D^2 / (nCd^2)]^2$$

Earlier difficulties with high-pressure individual-pump injection are reflected in the bewildering variety or more or less complicated fuel-pump and spray devices to be seen in current practice or described in patent specifications. The state of affairs is similar to that in the early development of carbureters, spark-plugs and magnetos. which has been followed by the present standardization of types on which the success and the low initial cost of the gasoline engine of today are based.

Enterprising specializing firms have already begun a similar standardization process and quantity production of fuel-injection parts which will no doubt contribute immensely to the future commercial success of

the high-speed Diesel engine. This standardization naturally has been concentrated on the individual-pump system, with the result that reliable and comparatively cheap pumps and injection valves are now on the market. Details of individual-injection-pump and injector designs were described last year in a paper[3] by J. E. Wild.

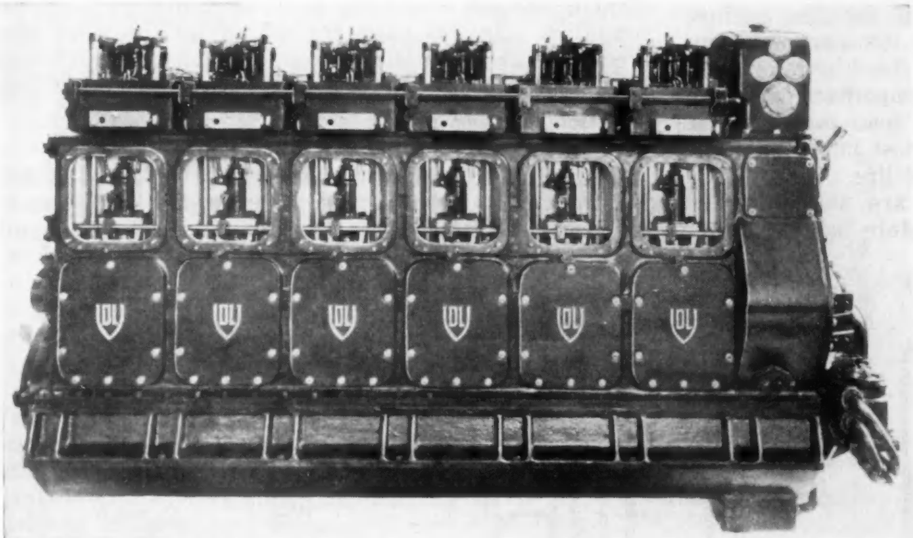

FIG. 11—DELAVERGNE SIX-CYLINDER 9 X 11-IN. ENGINE WITH VALVE COVERS REMOVED

The Instruments Shown at the End Indicate the Pressures of Fuel, Oil and Air and the Engine Speed. A Pyrometer Is Located at the Front of the Same Housing

For maximum mean effective pressure and greatest reliability our problem now is to select the simplest satisfactory injection design and apply it to our single combustion-chamber. Consequently, our choice falls on the pump design in which the plunger acts as inlet and bypass valve and on the closed-type nozzle having a spring-loaded valve which is opened by the pressure in the discharge line from the pump.

The pump units of an engine can be built in one block, as seen in Fig. 6, but it is preferable to mount them individually on a common housing of the plunger drives. Usually a separate camshaft is provided for driving the pumps. Individually mounted pump units give the advantage of greatest possible standardization and simplify the stock and the replacement problem. The simplest manner of driving such pumps is to place them over the camshaft that operates the inlet and exhaust valves, as has been done in the engine shown in Fig. 11. This camshaft is liberally dimensioned and rigidly supported in the crankcase, so that no deflection can occur which will disturb the injection timing. This arrangement also makes the discharge pipes short and of equal length for all cylinders.

Much controversy has centered around the question of open versus closed nozzles. The more simple open nozzle is unsuitable for variable-speed engines because the injection pressure varies with the square of the speed. The injection pressure is low at the beginning and end of each injection at any speed, and consequently the atomization is coarse. Also after-dripping of fuel occurs, due to the elasticity of the previously stressed pump plunger, discharge line and column of fuel.

The closed nozzle can be set to a definite opening pressure by adjusting the spring tension on the valve. It remains closed until this pressure is reached and closes instantly when the pump pressure drops. To make the advantages of the closed nozzle clearer, I refer to the example given in Fig. 10. The calculated injection pressure P_i at the beginning of injection is 4200 lb. per sq. in. at 750 r.p.m. The opening pressure of the injection valve was set to 3000 lb. per sq. in. when discharging into the atmosphere. When the speed of the pump is reduced, the injection pressure drops in proportion to the squares of the speeds; for instance, P_i is 915 lb. per sq. in. at 350 r.p.m. The pump pressure P_p is in each case approximately 650 lb. per sq. in. higher, because of the gas pressure in the combustion-chamber into which the fuel is injected and the fluid friction in the discharge pipe. The calculated initial pump pressure of 1515 lb. per sq. in. at 350 r.p.m. must then be built up to 3650 lb. per sq. in. before the valve is opened. After this the fuel is injected at a pressure of 3000 lb. per sq. in., which is high enough to give the desired atomization at slow speed.

May Omit Timing Control

The ignition delay, estimated in our example to be approximately 0.0018 sec. or 8 deg. on the crank circle at 750 r.p.m. as shown in Fig. 8, would require only 3¾ deg. at 350 r.p.m. if completed in the same time. In view of this it might seem that the injection timing could be retarded from 16 to 12 deg. in advance of dead-center. However, the actual beginning of injection at the reduced speed is retarded automatically by the necessity for building up the initial pressure to the injection pressure that has been predetermined by the adjustment of the injection valve, so that it is practicable to leave the ignition timing fixed over a wide range of speed. The injection advance, given in Fig. 8 as 16 deg., covers the ignition lag and also a certain injection delay due to the elastic deflection of the roller guides and other parts of the fuel-pump drive.

With a closed nozzle and a fuel-pump such as is shown diagrammatically in Fig. 9, the opening pressure is built up shortly after the inlet ports of the pump have been closed by the plunger. At this point—which is marked on a small inspection window provided on the fuel-pump housing, to facilitate accurate mounting and timing—the plunger has been lifted a certain distance, designated in Figs. 9 and 10 as idle lift. The cam setting is then simply advanced from this point, which was 16 deg. in our example. The pressure rise during combustion can be regulated at will by changing the injection timing. Our calculated pump pressures, as shown graphically in Fig. 10, checked fairly closely with measurements taken during engine operation.

Careful provision should be made to catch and drain off any possible leakage of fuel from the injection parts, if they are fully enclosed within the engine as in Fig. 11, to prevent dilution of the lubricating oil.

[3] See S.A.E. JOURNAL, May, 1930, p. 587.

Available Materials Limit Practicable Heat

Coming now to the practical application of the combustion principles discussed above to the design of cylinder-heads, valves, cylinders and pistons, it may be said that what now limits mean effective pressure is not combustion but the heat-resisting properties of the materials ordinarily available for these parts. Mean effective pressures equal to those of gasoline engines are possible in Diesel engines. The temptation to increase the rated power output to the highest values in this way is strong, because of competition with the gasoline engine, and it is bound to lead to trouble if it is not curbed by regard for the most important considerations of engine reliability and life.

Test rating and service rating are two different things. This fact, which unfortunately has been forgotten in some cases, should always be borne in mind. The rating of an engine is a difficult subject on which to agree, but it may be a sound rule that the normal service rating should be based on a mean effective pressure about 15 to 20 per cent less than that which the engine can deliver on the test floor for say 100 hours continuously without a hitch. Such a rating ordinarily coincides with the point of minimum fuel consumption. On this basis the ratings of the more progressive high-speed Diesel engines compare very favorably with those reported for heavy-duty gasoline engines.

Design of Cylinder-Head and Valves

The cylinder-head, which is usually made of nickel cast-iron, contains the inlet, exhaust and fuel valves and has to resist stresses from both gas pressure and

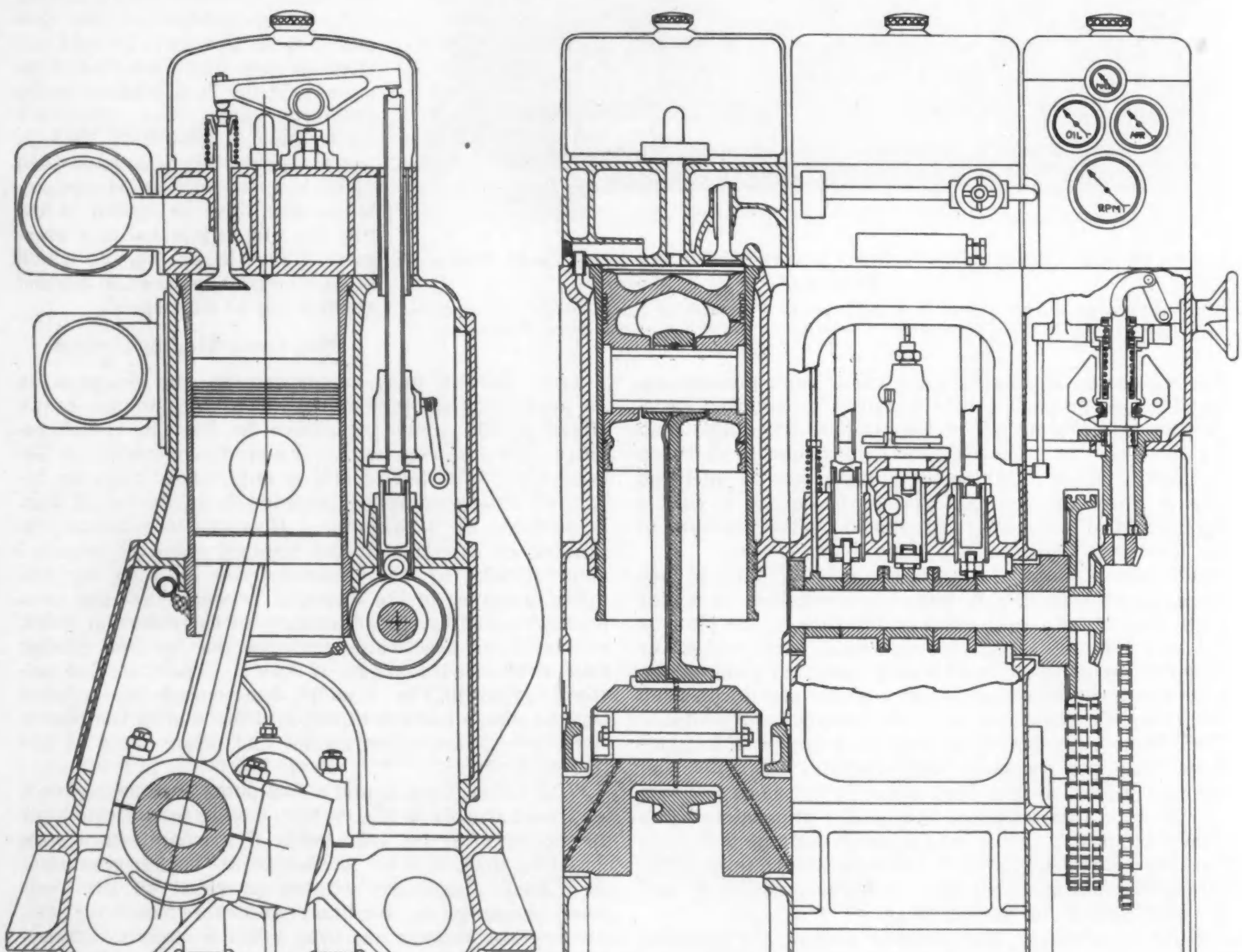

FIG. 12—TRANSVERSE AND PARTIAL LONGITUDINAL CROSS-SECTION OF DELAVERGNE 9 X 11-IN. HIGH-SPEED DIESEL ENGINE
Air Enters at the Dual Inlet Valves from the Lower Manifold through a Short Passage, Partly Vertical, Having Directing Fins as Indicated in Fig. 5

heat. It consists mainly of two discs connected by a vertical shell of suitable height and by the bosses for the valves. To limit the heat stresses in the bottom disc, which is exposed directly to fire and pressure, ample cooling-water should be splashed against the center and particularly around the fuel valve, where heat tends to be localized.

In the DeLaVergne cylinder-head, shown in cross-sections in Fig. 12, the cooling water enters through a nipple at the bottom and flows toward the center at high velocity through a horizontal port cast inside the head. From there it spreads out to cool the hot lower disc, the five valve-bosses and the inlet and exhaust ports. The bottom disc is well supported from the top disc through the inner vertical shell and the vertical valve-bosses, so that it can be made thin to avoid undue heat stresses. The top disc is extended into a square flange, supported by high outer walls. Vertical ribs between the inner and outer shell reinforce this boxlike head, assuring great rigidity. This allows the gas pressure to be transmitted to the frame by a small number of strong bolts, making removal of the head easy.

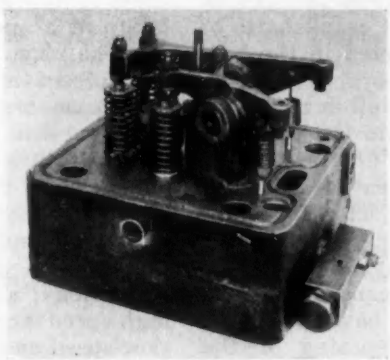

Fig. 13—Cylinder-Head of Engine Shown in Figs. 11 and 12

Valves and ports should be unrestricted, the valve lift should be at least 25 to 30 per cent of the port diameter and the inlet valves should be well streamlined. The 30 or 45-deg. valve seats should be made wide enough so that the heat absorbed by the valve-head during combustion can be dissipated mainly through the seat, to prevent excessive heat and sticking of the valve-stem.

The larger a valve is, the hotter it gets; because the valve-head area exposed to heat increases with the square of the valve diameter, while the cooling surface at the seat increases only in direct proportion. It is therefore advisable to arrange dual inlet and exhaust valves in the larger cylinders, say from 7 to 8-in. diameter and upward. Smaller dual valves warp less, so that the time between regrinding operations is materially increased. Furthermore, ports for four valves give a more symmetrical cylinder-head design and more distance between the valve seats, which eliminates danger of cracking. Fig. 13 shows that the valve gear for dual valves can be made just as simple as for single valves.

Cylinders, Liners and Aluminum Pistons

Cylinders of high-speed engines usually are cast in one block, together with the crankcase, as shown in Fig. 14. The material is either cast iron or aluminum. Removable liners of hard nickel-iron or steel seem to have become common practice in both the larger and the smaller sizes. Where price permits, steel liners are an advantage in respect to wear and lubrication, because they are hard and can be made very thin and kept cool. Besides, a well-cooled liner increases the volumetric efficiency and dissipates more heat from the piston. There is no question that the steel liner will considerably outlive the cast-iron liner. Whether the use of nitrided steel for liners will be justified is a question of cost and future development; their cost now is prohibitive.

The piston has to fulfill many important requirements, which are much more severe in high-speed engines than in slower types. The piston should be as light as possible, to keep inertia forces low and thus reduce the average bearing pressure. Cast-iron pistons are too heavy for high speeds, and aluminum-alloy pistons are now available which give satisfactory service.

The greatest portion of the heat which the piston dissipates to the walls of the cylinder is conducted through the piston-rings. Properly drained and placed oil-wiper rings, possibly one near the bottom of the piston and one above the piston-pin as illustrated in Fig. 14, prevent lubricating oil from creeping up into the combustion-chamber. The piston-pin should not be located too close to the piston-rings, to avoid piston slap.

The Mechanics of High Speed

The mechanical problems arising from high piston and rotative speeds in Diesel engines are very similar to those encountered in high-speed gasoline engines. The general feeling among the older Diesel-engine users that increased speed means reduced reliability is no longer justified, because of the metallurgists' recent contributions of better materials, the higher standards of manufacturers, the wider experience of designers and our present knowledge of lubrication.

Due allowance must be made for the difference in maximum gas pressures in comparing the mechanics of high-speed engines. The problem of high speed and light weight consists, like most engineering problems, of a judicious compromise between daring attempts and safety first. The purpose of the following discussion is to indicate where conservatism and caution are necessary.

The chief problems in the design of the connecting-rods for high speed are: (*a*) sufficient stiffness to resist both bending and vibration, (*b*) light weight and (*c*) sufficient rigidity of the rod ends to provide adequate support for the bearings. The piston-pin bearing should be made short and of large diameter, to prevent local overloading. Uniform surface hardness is of utmost importance, therefore it is advisable to make the piston-pin of nitrided steel.

Heavy Carbon-Steel Crankshaft Recommended

The diameter of crankpins should be made as large as possible, preferably two-thirds of the diameter of the cylinder, which makes the big end of the rod about as large as can be removed through the cylinder. Sufficient bearing lengths are then obtained with a reasonable cylinder-center distance of about 1½ times the bore, without penalizing the thickness of crank webs. The webs must be made rigid to prevent deflection and whipping. A bearing is fitted between each two crank throws for the same reason. The flywheel-end bearing is usually made longer than the others. For most commercial purposes a well-forged 0.40 to 0.45-per-cent-carbon steel meets the two essential requirements of fatigue resistance and surface hardness. Apart from the advantage of lower price, a one-piece carbon-steel shaft is more dependable than a high-tensile-strength alloy-steel shaft because it is less sensitive to errors in heat-treatment.

Well-designed carbon-steel crankshafts seldom fracture if proper fillets are provided at the ends of journals and crankpins; if sharp corners and threaded plugs are avoided in the hollow crankpins; and, most important, if freedom from torsional vibration at any operating speed is assured. Rigid support of the main bearings in the bedplate or crankcase is equally vital to the life of the crankshaft and to smooth running of the engine. My excuse for mentioning this is that most crankshaft failures and bearing troubles are due to deflections and misalignment, giving reason to think that the importance of rigidity is not always sufficiently appreciated. The general gasoline-engine practice of fastening the main-bearing caps to the crankcase can be followed in small Diesel engines, but the crankshafts of medium-size engines usually are supported in the bedplate.

An efficient cooler for the lubricating oil is necessary in high-speed Diesel engines to maintain the temperature of the oil in the crankcase within practical limits of 150 to 175 deg. fahr. The use of a satisfactory oil-filter is also important. The limiting factor for high-speed-engine bearings is the pressure multiplied by the velocity; not the maximum pressure only. A product of pounds per square inch and feet per second as high as 20,000 is safe for main bearings which have force-feed lubrication and good facilities for disposing of the heat.

Engine Vibration and Critical Speeds

Crankcases and bedplates must possess sufficient rigidity to withstand deflection from the inertia and centrifugal forces in various directions. Too light a structure may allow serious vibrations even in an engine that is inherently well balanced, as are six and eight-cylinder engines. The cast-iron bedplate shown in Fig. 14 is light in weight but very stiff. It is well ribbed under each bearing and has rigid bearing caps snugly fitted into recesses and held by strong through bolts.

Torsional vibrations are a serious problem to be considered whenever a high-speed Diesel engine is coupled to a propeller, generator, pump, compressor or any other driven unit. Reliable methods of calculating and measuring torsional vibrations are available and can be successfully applied to avoid critical speeds, so that there is no excuse for operating a Diesel-engine installation at a speed that synchronizes with the period of the shafting. Nevertheless the Diesel-engine crankshaft frequently is the innocent victim of the vibrating masses acting through the driven shaft.

Engine life is another vital problem with high-speed light-weight engines. There is no apparent reason why an engine of this class should not last many years if it is handled with care and if proper overhauls and renewals are made from time to time. Other things being equal, wear is a function of the total number of revolutions; and it would not be fair to expect from a high-speed engine as many hours' service as from a slow-speed engine without spending a little more money for upkeep during the same service period. All modern engines are designed for the ready replacement of such parts as pistons, piston-rings, bearings, liners, valves and injection parts, and renewals take but little time because of the small size and ease of handling of the parts.

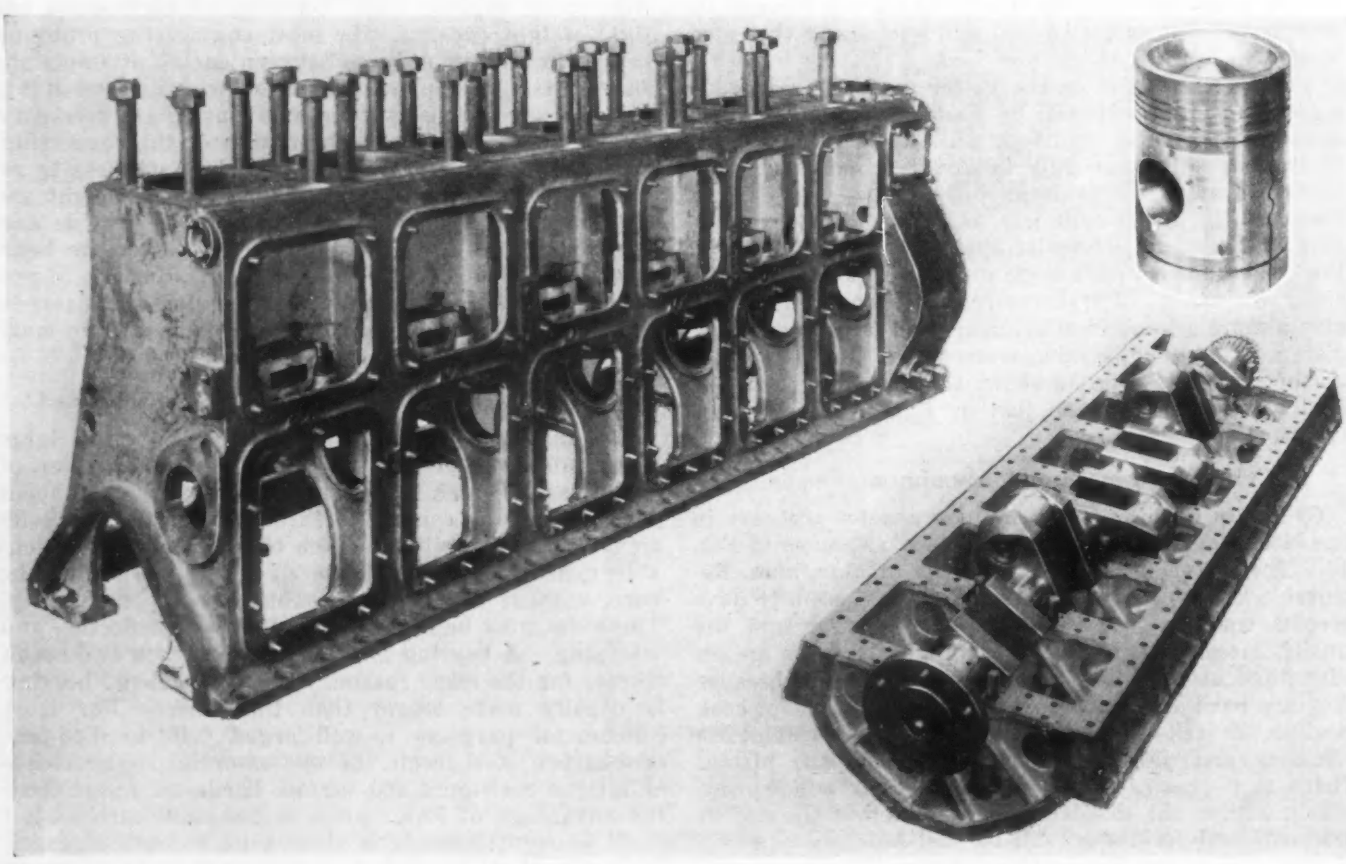

Fig. 14—Details of DeLaVergne 9 x 11-in. Engine

Development of the Franklin *Direct Air-Cooled* Engine

Annual Meeting Paper

By E. S. Marks[1] *and* C. T. Doman[2]

FEATURES of the design of the various cylinders built by the Franklin organization in its development program leading up to the present design are discussed in this paper. The relation of waste heat to cooling-fin areas and cooling-blast velocities is shown and discussed for cylinders up to 3½-in. bore.

Characteristics of the cooling system, including fan, fan housing and air housings, are discussed at length, and the authors contend that no more power, if as much, will be absorbed in the cooling system as in that of the indirect air-cooled engine. Results of tests showing the ability of the engine to cool under the severest conditions of load and temperature are given.

Since the quietness of any engine is dependent upon constant valve-clearances, the authors describe in detail the method followed in the Franklin design to maintain at less than 0.003 in. any variation in clearance. A careful analysis is made for each part in the valve-gear mechanism that is affected by expansion.

Power curves of earlier engines built by the company are compared with the present-production powerplant. Without a change in piston displacement, the brake horsepower at 3500 r.p.m. has been increased by 76 per cent. This increase has resulted from (*a*) better cooling characteristics of the cylinder, (*b*) increased valve area, (*c*) decreased absorption of power by the fan and (*d*) increased compression-ratio.

FUNDAMENTALLY, all automotive engines are air-cooled. Yet, as engineers, we are most likely to designate the type of cooling by either "water-cooled" or "air-cooled." More correctly, we should use "indirect air-cooled" for the conventional type, or "direct air-cooled" when referring to engines cooled without an added medium. To this latter class the Franklin engine belongs.

In the past the direct air-cooled engine was handicapped by the fact that the power output was limited by inability to cool the cylinder properly. Consequently it was assured that, if a cylinder which had satisfactory heat-dissipating characteristics were developed, a power output comparable with that of the indirect air-cooled type of cylinder would be obtained. This paper deals with the development of a cylinder capable of delivering power output and of dissipating waste heat as well as, if not better than, the indirect or water-cooled type.

Experimental Cylinders

Fig. 1 shows the conventional cylinder as used on Franklin engines up to the introduction of the present type of side-draft cooling. This cylinder has a cast-iron barrel with fins cast in place on the first engines and arc-welded in place on later engines. Prior to 1925 the cooling fins were of steel. However, in that year a foundry method was devised for satisfactorily casting-in copper fins. This type of cylinder, of 3½-in. bore and 4¾-in. stroke, used 114 fins each 0.05 in. thick, this thickness and fin number having been found to dissipate the greatest quantity of heat with a given air-flow. The path of the cooling air, as indicated by arrows in the drawing, is first directed by air deflectors onto the head and then down the fin cells.

With this design the cylinder-head lacked sufficient cooling area to dissipate any great quantity of heat without resorting to high head-temperatures. High head-temperatures resulted, however, in excessive exhaust-valve and exhaust-valve-guide temperatures. Temperatures of 800 deg. fahr., measured in the bridge between the valves, were not uncommon under continuous wide-open-throttle operation. Furthermore, even had it been possible to cool the cylinder, the breathing capacity of the engine was limited by the valve sizes. Since the total of the diameters of the two valves plus the bridge thickness could not be greater than the cylinder bore, small valves were a necessity. Consequently, the conclusion was reached that an entirely new design, combining increased cooling ability with increased valve sizes, was necessary.

The first step in this development program is shown in Fig. 2. This cylinder was built with a detachable aluminum head which carried a large exhaust-valve. The cylinder barrel carried the intake valve. Studying this figure carefully, one can see the difficulties that might and, in fact, did arise. The cooling blast was directed to the various cylinders only by using a complicated system of deflectors, and then passed into the copper-fin cells on the barrel by a series of contortions. This tortuous air-path resulted in a system of very high resistance which severely lowered the fan efficiency. The whole story of this engine was one of grief. Cylinder-head gaskets could not be kept tight; valve clearances varied from 0.005 to 0.050 in.; the cylinder barrel around the intake valve became hot and distorted; and the cooling fan required excessive power to push the necessary air-flow through the restricted passage. Yet, with all these disappointments, the engine showed that increased power could be obtained by increased valve areas. Furthermore, had we then had the foresight to use a side-blast type of cooling, this engine would without doubt have shown remarkable performance. Experiments were continued with it for a time but were later abandoned for the cylinder type shown in Fig. 3.

The design in Fig. 3 followed former Franklin prac-

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[2] M.S.A.E.—Research engineer, H. H. Franklin Mfg. Co., Syracuse, N. Y.

tice in a general way except that the cylinder-head was removable, carried valves of generous size and was literally covered with cast-in copper fins. Power tests showed exceptionally high output until the fan drive was taken into account. Again the high resistance of the air passage resulted in excessive power absorption by the fan. The results therefore indicated that the successful design must incorporate not only increased cooling ability and increased valve areas but a third

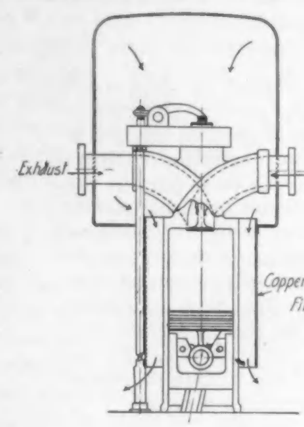

Fig. 1

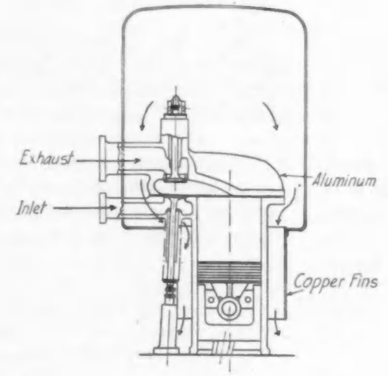

Fig. 2

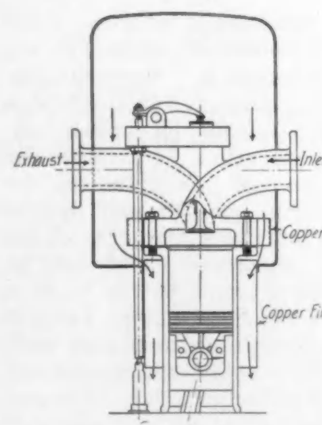

Fig. 3

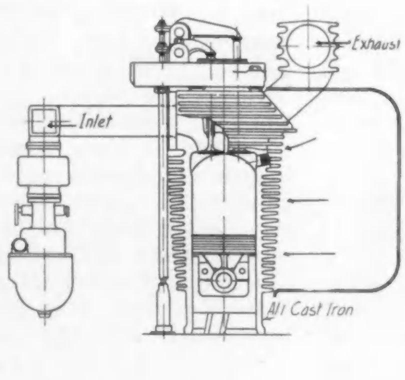

Fig. 4

Fig. 1—Conventional Down-Draft Cylinder Used from 1909 up to Introduction of Side-Draft Cooling. The Vertical Cooling-Fins Were of Steel until 1925, When Cast-in Copper Fins Were Introduced

Fig. 2—Experimental Cylinder with Detachable Aluminum Head, Which Was the First Step in the New Program. The Tortuous Path of the Cooling Blast Caused Many Troubles

Fig. 3—Side-Blast Cylinder with Removable Cast-Iron Head and Large-Sized Valves. This Developed High Power-Output Except for Excessive Power-Consumption by the Fan, Showing the Need for a Low-Resistance Air Circuit

Fig. 4—First Side-Blast Design Departing Greatly from Earlier Designs but Returning to Horizontal Fins Used on Earliest Franklin Engines. Experience with This All-Cast-Iron Cylinder Led to the All-Aluminum Cylinder Having a Shrunk-in Cast-Iron Liner

Steps in Development of the New Franklin Air-Cooled Cylinder

factor; that is, an air circuit of low resistance. These conclusions led to the design shown in Fig. 4.

This design is seen to depart greatly from those already discussed, yet the horizontal cooling fins were used on the company's earliest engines and later abandoned for the radial or vertical type of fin. This was an all-cast-iron cylinder. The valves were arranged at 45 deg. to the longitudinal axis of the engine and were of necessity small. Continuous-load tests showed this engine to have low power-output and that the cylinder was not capable of dissipating sufficient heat. Troubles were experienced from hot-spots and sticking pistons. The experience with this cylinder led to the decision to try an all-aluminum cylinder having a shrunk-in cast-iron liner, which is shown in Fig. 5.

This cylinder cooled very satisfactorily and demonstrated that cast iron must be eliminated as a cylinder-head material for a high-capacity engine and that aluminum held most promise. The power output, however, was very disappointing. This condition was again traced to insufficient valve area and to excessive power-absorption by the cooling fan. Therefore we decided to build a cylinder having a detachable head combined with a cast-iron barrel. Such a design is illustrated in Fig. 6.

An aluminum head well covered with cooling fins and incorporating very generous-sized valves characterized this design. The valve seats were of aluminum bronze with a 0.003-in. shrink fit. The head was bolted to the cylinder barrel with six bolts pressing against a copper-asbestos gasket. Cooling air was directed to the exhaust port, then to the intake port and intake manifold. The valve-gear box was bolted directly to the upper surface of the cylinder-head in much the same way as in the conventional Franklin construction shown in Fig. 1.

Initial tests of this engine were discouraging as regards power output, yet they demonstrated that the cylinder cooled beautifully and that the joint between the cylinder-head and the barrel was a practical construction. Investigation showed that the low power of the engine was due to excessive power-consumption by the fan, low compression-ratio and overheating of the intake gases.

A careful study of cylinder temperatures promptly showed that the fan was delivering an excess quantity of air, since the engine temperatures were too low. Consequently, a new fan was designed which consumed 8.5 hp. at 3000 r.p.m. as against 19.7 hp. and resulted in cylinder-head temperatures well below 600 deg. fahr. The compression ratio was raised from 4.7 to 5.1:1, as absolutely no detonation was audible at any speed. The final investigation in the power study demonstrated immediately that the valve ports required reversing. Under continuous heavy load the cylinder-head absorbed a great quantity of heat, which flowed out into the intake manifold and thus excessively increased the gas temperatures. We found that, after a wide-open-throttle run at 2500 r.p.m. and then slowing down to 1000 r.p.m., the intake-gas temperatures would reach as high as 300 deg. fahr. With this in mind, the cylinder was next built as shown in Fig. 7, realizing that we were gambling with our ability to cool the exhaust valves properly.

The intake manifold in this design was removed absolutely from the airstream. However, the blast from the fan first struck the intake ports and then impinged on the hot exhaust-ports. The cylinder-head was again fastened to the barrel by six bolts, but the bolts were extended down through the barrel fins, with the nuts resting on a heavy boss. This construction was followed

because a detachable head that would not necessitate removal of the cylinder barrel was desired. Also, it left space at the top of the cylinder barrel for two extra cooling fins. Initial tests of this design showed the power output to be beyond expectations. Cylinder temperatures were low, yet two very discouraging features became evident: The valves were noisy because of excessive change of clearance, and the cylinder barrels persistently cracked just beneath the lower fin. After many attempts to eliminate the cracking, we decided to revert to the bolting method of Fig. 6, which had proved satisfactory.

Maintenance of Constant Valve-Clearance

The problem of maintaining constant valve-clearance was the most trying of any encountered during the development program. Thirty-four distinct steps were made before the final solution was obtained. Each step was particularly analyzed as to result, and with the fund of information thus accumulated it is now possible to calculate quite accurately the probable characteristics of an experimental valve-gear.

Early in this study we found that no particular effort was required to maintain constant valve-clearance on either valve alone, but when an attempt was made to compensate both valves together for all conditions of load and speed, serious difficulties arose. When the valve-gear was designed to maintain constant intake-valve clearance, the exhaust-valve clearance would decrease as much as 0.020 in. On the other hand, when the exhaust-valve clearance remained constant, the intake clearance would increase by 0.025 in. Either of these two conditions was, of course, inadmissible. Analyzing the various effects in the valve-gear set-up we had the following:

Increase of cylinder temperatures due to load, as a result of which the

(1) Exhaust-valve stem increased in length a maximum of 0.020 in.
(2) Intake-valve stem increased in length a maximum of 0.004 in.
(3) Exhaust-valve-stem expansion depended on intensity of flame, characteristics of valve guide and valve-guide boss, valve-stem length, heat conductivity of valve-seat and temperature of head metal backing up the seat, quantity of cooling air, arrangement of finning on the head, angle of valve seat, proportioning of metal in the valve head and, finally, expansion characteristics of the material.
(4) Intake-valve expansion depended on all items listed in (3) but to a less extent.
(5) Push rods elongated by 0.005 in., which equals 0.010 in. at the valve-stem.
(6) Cylinder assembly expanded vertically 0.030 in.; the barrel expanding 0.010 in. and the cylinder-head 0.020 in.
(7) Push-rod tubes increased in diameter by 0.007 in. and tended to offset partly the push-rod expansion.
(8) Distortion in valve-gear-mechanism parts represented an equivalent increase in clearance at the valve-stems of 0.009 in.

When each of the foregoing characteristics is studied, it is seen that constant valve-clearances in an air-cooled engine are to be obtained only after consideration for every effect.

The final solution consisted in mounting the valve-gear box on two studs marked *A* and *B* in Fig. 9. These studs are extensions of two of the bolts used for fastening the cylinder-head to the barrel. A third stud, *C*, which is a compensating stud, is the most important item in the design. It is screwed into the cylinder-head and rests on a shoulder that is level with the exhaust-valve seat. As the exhaust valve expands with increased temperature, it rises vertically and would take up all tappet clearance and remain open if it were not for the compensating stud, which rises vertically because of expansion of the length of aluminum beneath it. This

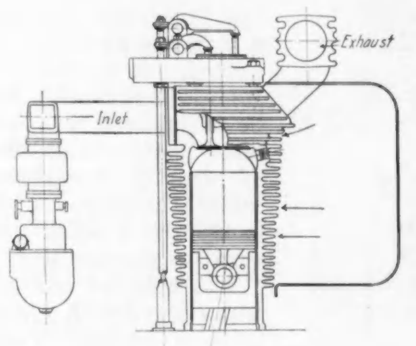

Fig 5

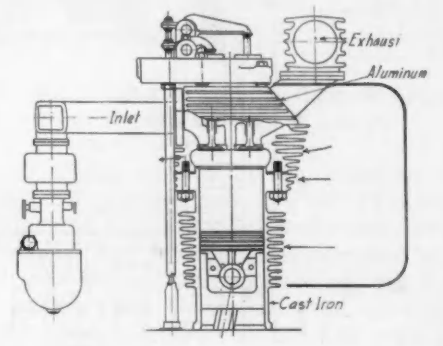

Fig. 6

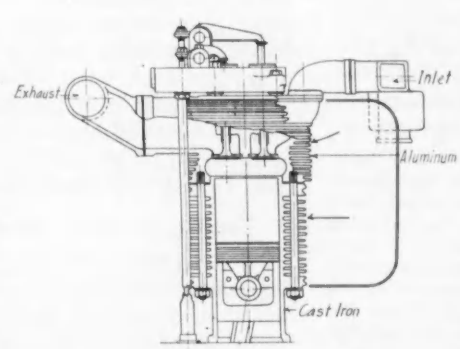

Fig. 7

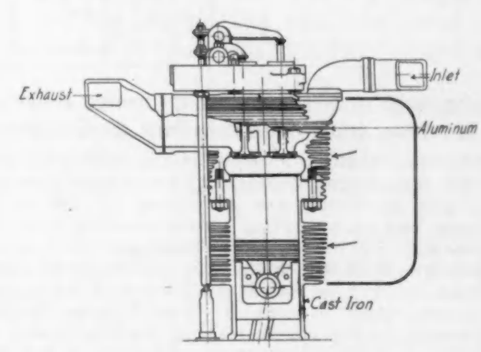

Fig. 8

Fig. 5—All-Aluminum Side-Blast Cylinder with Cast-Iron Liner. This Cooled Very Satisfactorily but the Fan Absorbed Too Much Power, and a Return to the Detachable Head Was Decided upon

Fig. 6—Design for Cast-Iron Cylinder-Barrel and Detachable Aluminum-Head. Initial Tests Showed That Low Output Was Due to Power Consumption by the Fan, Low Compression-Ratio and Overheating of Intake Gases

Fig. 7—Design with Gas Inlet on Air-Blast Side and Airstream Directed First against the Intake Port and Then against the Exhaust Port. Note Long Hold-Down Bolts for Aluminum Cylinder-Head

Fig. 8—This Design Is Similar to That in Fig. 7 but Shows a Reversion to the Short Hold-Down Studs as in Fig. 6 to Prevent Cracking of the Cylinder Barrels Directly beneath the Lowest Cooling-Fin

Further Successive Designs Leading up to the Present Efficient Cylinder

vertical movement rocks the fulcrum of the exhaust-valve walking-beam and thus maintains nearly constant clearance at the valve. Table 1 gives actual valve-clearances as measured on an engine and which represent normal performance.

General Construction of Present Engine

Essentially, the cylinder construction shown in Figs. 8 and 9 and the valve-clearance-compensation idea just discussed are now used in the production engine shown in Fig. 10. This engine has six cylinders of $3\frac{1}{2}$-in. bore and $4\frac{3}{4}$-in. stroke. It has a compression ratio of 5.3:1, although this does not by any means represent the maximum possible. The construction below the lower cylinder-flange follows normal practice. Cooling air is supplied by a 15-in. centrifugal blower mounted on the crankshaft. This air is directed to the various cylinders by a duct along the left side of the engine. The air leaving the cylinder is directed downward by another duct or housing so that no heat dissipated by the cooling system can enter the interior of the car.

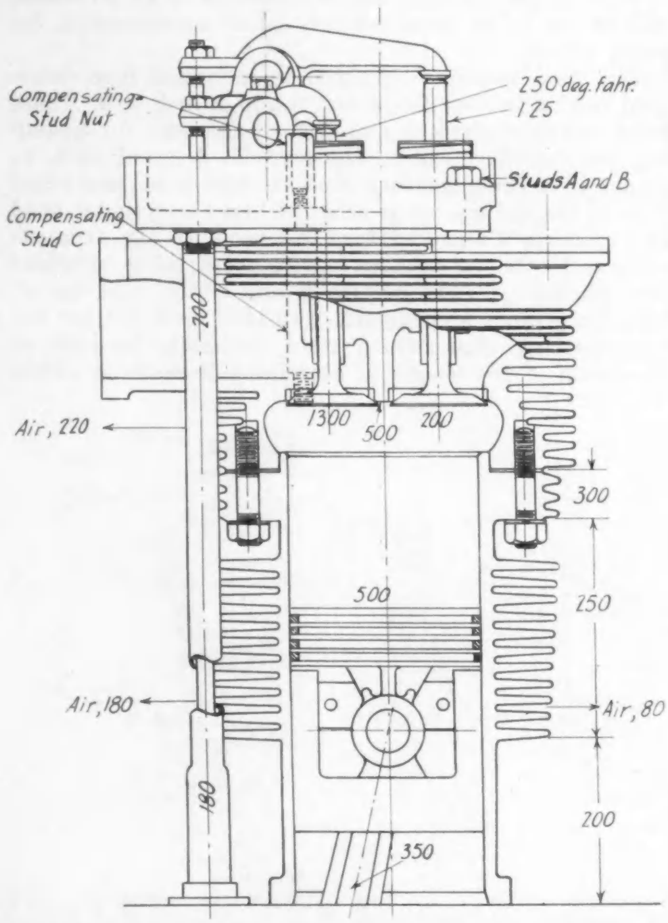

FIG. 9—FINAL DESIGN OF CYLINDER USED IN PRESENT ENGINE, WITH TEMPERATURES AT VARIOUS LOCATIONS

The Most Difficult Problem of Maintaining Constant Valve-Clearance Was Solved by Mounting the Valve-Gear Box on Two Studs, *A* and *B*, Which Are Extensions of Two Cylinder-Hold-Down Bolts, and Incorporating a Compensating Stud, *C*. The Latter Is Screwed into the Cylinder-Head and Rests on a Shoulder Level with the Exhaust Valve. As the Exhaust Valve Expands with Heat, Stud *C* Is Raised by Expansion of the Aluminum of the Cylinder-Head beneath It. This Vertical Movement Rocks the Fulcrum of the Exhaust-Valve Walking-Beam, thus Maintaining Nearly Constant Clearance at the Valve

TABLE 1—AVERAGE VALVE-CLEARANCES IN PRESENT DESIGN UNDER NORMAL OPERATION

	Exhaust Valve, In.	Intake Valve, In.
Engine Idling, 200 R.P.M	0.006	0.003
20 M.P.H., Level-Road Load	0.007	0.004
40 M.P.H., Level-Road Load	0.007	0.003
60 M.P.H., Level-Road Load	0.006	0.003
70 M.P.H., Full Load	0.004	0.002

Characteristics of the Production Cylinder

The cylinder-head is cast of Y alloy, either in a sand mold or a permanent mold, as this metal is the only material we have found that will long withstand continuous full-load operation and maintain tight gaskets and good conductivity between the valve seats and the cylinder-head proper. It also assures absolute tightness of the studs threaded into the head. Loose studs are very common with inferior materials.

Each cylinder-head has a total radiating area of 494.8 sq. in. This represents 7.22 sq. in. per cu. in. of piston displacement and 34.1 sq. in. per b-hp. output. Extensive investigations have shown that these relations are best suited for cylinders up to $3\frac{1}{2}$-in. bore in which a temperature of 500 deg. fahr. is the maximum. This figure of maximum temperature is taken between the valves and is measured by a thermocouple 1/32 in. from the inner combustion-chamber surface. No doubt a temperature higher than 500 deg. fahr. could be permitted, but we feel that this is absolutely safe practice for aluminum-alloy heads. In this connection it may be of interest to mention that our maximum cylinder-head temperatures were lowered 50 deg. fahr. simply by bringing the exhaust and intake ports together by a metal thickness of $\frac{1}{2}$ in. Although, offhand, this looks like a small change, it alone did the most to equalize temperatures throughout the head.

The cylinder barrel is of a good grade of cylinder iron alloyed with 1 per cent of nickel. It represents no unusual foundry practice except that extra precaution is taken to remove all flash from between the fins. The fins are cast on $\frac{3}{8}$-in. centers and are rather deep. Each cylinder barrel has a total radiating area of 590 sq. in., or 8.6 sq. in. per cu. in. of piston displacement. Various cylinder barrels have been developed that combine cast iron with welded-copper fins, aluminum with ordinary cast-iron liners and aluminum with liners of high nickel-content. However, we have yet to see a cylinder that in all respects is an equal of the cast-iron barrel just discussed.

Cooling-System Construction and Performance

Next to the cylinder construction, the cooling system deserves most consideration. By cooling system is meant the cooling fan, the fan housing and the air ducts. In previous air-cooled engines the fan has always been a sore subject. It gloried in absorbing a large proportion of the power output. We feel, however, that this is past history in view of the performance of the present fan. This absorbs 4.2 hp. at 3000 r.p.m. and delivers 3920 cu. ft. of air per minute against a static head of 4 in. of water. This represents an air efficiency of 56.2 per cent, which is admittedly high. At 3500 r.p.m. the fan absorbs 6.7 hp. with a proportional increase in air delivered. These figures for power absorption represent the total power taken up in cooling the engine. We believe that this is as low as, if not lower

than, the power absorbed by fan and water pump on indirect air-cooled, or, as generally designated, water-cooled, engines of equal piston displacement.

Discussion of the characteristics of the centrifugal type of fan used may be desirable here, since automotive engineers are perhaps better acquainted with the propeller type. In general, three types of blade are used in centrifugal fans. They are straight, forward curved or backward curved, depending upon the limitation of design. For a given diameter of fan, the forward-curved blade will give the most pressure, as shown in Fig. 11. Any centrifugal fan has two distinct sources of pressure: first, centrifugal force resulting from rotation of the air within the fan; and, second, kinetic energy imparted to the air by its velocity on leaving the periphery of the fan. Before the kinetic energy of the air is serviceable, it must first be converted into potential energy in the form of static pressure. This is the duty of the fan housing, or scroll, as it is sometimes designated.

The resultant line *P* in each of the diagrams *A*, *B*, and *C* in Fig. 11 represents the actual velocity of the air as referred to the fan housing. The present production engine uses the backward-curved blade as shown in *B*. This fan is found to be much more efficient than those having either of the other blade types. The forward-curved type was used on the 1930 engine. It had a diameter of 12 in. and 55 blades, whereas the present fan is 15 in. in diameter and has but 32 blades. The first experimental fans having backward-curved blades had 66 blades, but blades were removed step by step until 32 was arrived at as the most practical number. Fans having only 12 blades were built and found to have the same efficiency as the fan with the number selected. We felt, however, that such a fan would lack sufficient rigidity to withstand speeds which at times might exceed 4200 r.p.m. Table 2 compares the performance of the present fan with that used on the 1930 engine, and Fig. 12 shows the 1931 fan beside last year's fan.

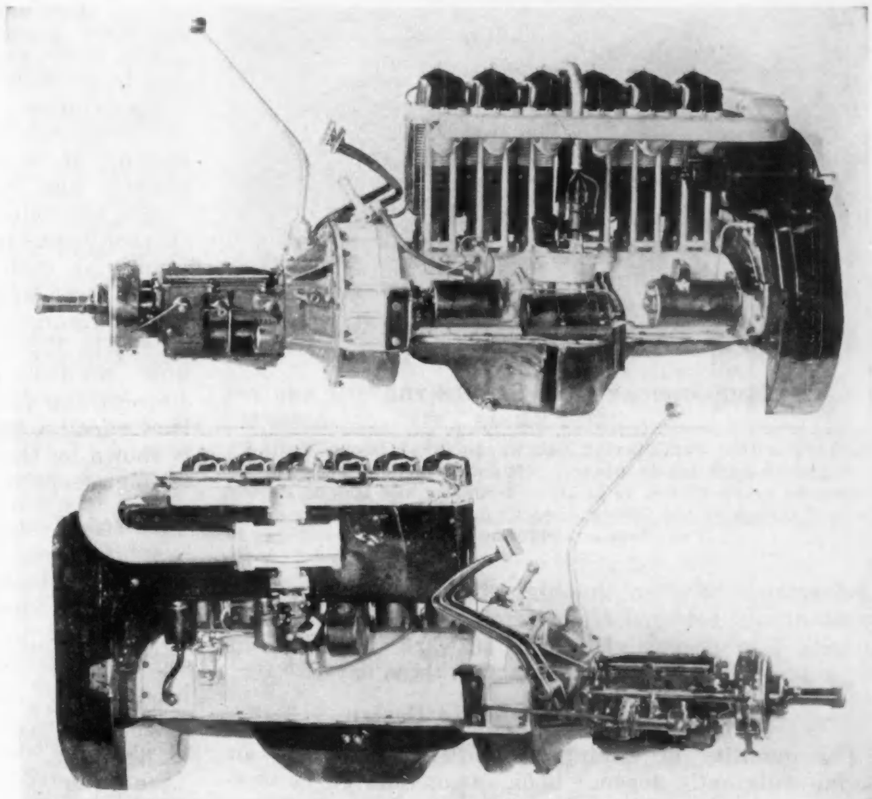

FIG. 10—RIGHT AND LEFT SIDES OF 1931 FRANKLIN DIRECT-COOLED ENGINE EMBODYING CYLINDER CONSTRUCTION SHOWN IN FIGS. 8 AND 9

TABLE 2—COMPARISON OF PERFORMANCE OF 1930 AND 1931 FANS

1930 Fan, 12-In. Outside Diameter, Forward-Curved Blades			1931 Fan, 15-In. Outside Diameter, Backward-Curved Blades		
Speed, R.P.M.	Power Absorption, Hp.	Air Delivered per Minute, Cu. Ft.	Speed, R.P.M.	Power Absorption, Hp.	Air Delivered per Minute, Cu. Ft.
1,000	0.32	1,230	1,000	0.15	1,310
1,500	1.10	1,850	1,500	0.52	1,960
2,000	2.50	2,460	2,000	1.24	2,620
2,500	4.80	3,080	2,500	2.36	3,270
3,000	8.50	3,700	3,000	4.20	3,920
3,500	14.50	4,320	3,500	6.70	4,580

The design of the air housing is fully as important as that of the fan itself. No laws can be stated for a most efficient shape, and if there were definite laws they could not be used, because of chassis limitations. The

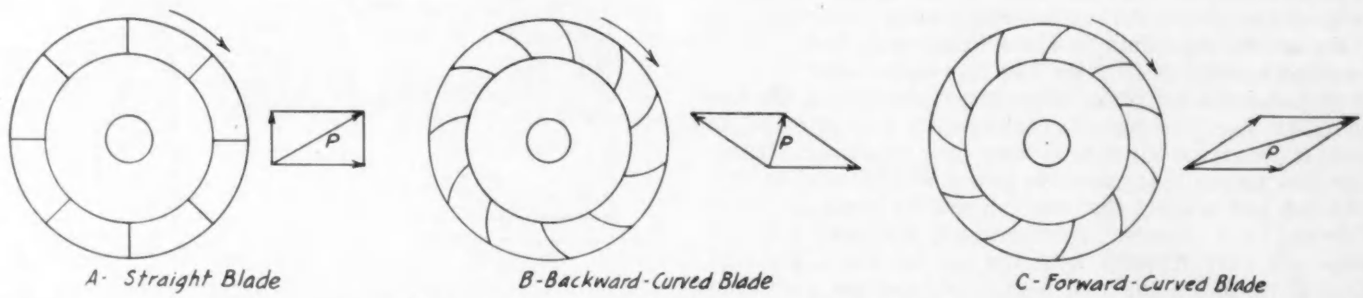

FIG. 11—BLADE FORMATION OF CENTRIFUGAL COOLING-FANS AND CORRESPONDING AIR VELOCITIES DELIVERED TO FAN HOUSING

The Fan Having Backward-Curved Blades (*B*) Is Much More Efficient than the Other Two Types and Is Used in the 1931 Engine. Kinetic Energy in the Air Leaving the Fan Is Converted in the Fan Housing into Potential Energy in the Form of Static Pressure, *P* in the Diagram at the Right of Each Fan

FIG. 12—COMPARISON OF FANS USED IN THE 1931 AND THE 1930 ENGINES

(Left) The 1931 Fan, Having Backward-Curved Blades, Is 15 In. in Diameter and Has 32 Blades. (Right) The 1930 Fan, Having Forward-Curved Blades, Is 12 In. in Diameter and Has 55 Blades. Table 2 Compares the Power Absorption and Air Delivery of the Two Fans at Different Speeds

performance of even the high-efficiency fan could be substantially bettered if it were possible to make the housing 1 in. deeper. However, outward appearance of our automobiles is very important in these days.

Heat Balance as Related to Design

The quantity of cooling air necessary to cool an engine sufficiently depends upon various design-factors, and these are variable and complicate any preliminary computations. Nevertheless, we have collected data through the development of these various engines to enable us to calculate the performance quite accurately before the engine is built. In these calculations we generally assume that the cylinder must be capable of dissipating 35 per cent of the total energy contained in the fuel, because we have measured the actual heat-balance on certain engines and found, for example, that an engine operated at 3000 r.p.m. gave the following results:

	Per Cent
Heat Equivalent in Useful Work	25
Heat Loss through Exhaust	37
Heat Loss through Cooling System	35
Unaccounted for	3
Total	100

Of course, once an engine is on the dynamometer, it is easy to check our design figures and, if necessary, to change the cooling system to give the desired results. For example, if 500 deg. fahr. is the maximum allowable temperature for valve-bridge metal and 400 deg. fahr. is the maximum on the cylinder-wall, the simplest method usually is to alter the fan blade until the air-flow is correct for these temperature conditions. If the cylinder has insufficient cooling-area, to attempt to cool it by excess air-flow is very poor practice. Excess air-flow means that excessive power will be absorbed by the fan and usually that the fan will be much too large for use in a chassis. Furthermore, the heat removed does not vary directly with the air velocity. We find that if we plot a curve of heat dissipated per unit area against air velocity, the resulting curve is very similar to the magnetization curve for iron; that is, the curve rises quite rapidly and then flattens off quite suddenly. The best practice is to work below the "knee" of the curve.

Uniformity of Cylinder Temperatures

One other factor that enters into this air-flow subject is the distribution of the air to give equal cylinder temperatures. A poor engine results if five cylinders are adequately cooled while the remaining one is undercooled. It is much better to raise all temperatures slightly and have the cylinders cooled equally. To assure this condition, our usual practice is to place four thermocouples in each cylinder barrel and at least three couples in each cylinder-head. The air housings are then altered until comparative locations show temperature differences of not more than 20 deg. fahr. Reference to Fig. 13 will show the air-housing construction. No deflectors are used, correct distribution of the air resulting from the shape of the side of the housing. How effective this method of air distribution has proved is shown by the following temperature figures taken at an engine speed of 3000 r.p.m.

Head Temperature between Valves, Deg. Fahr.

Cylinder					
No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
500	510	508	510	490	490

Cylinder-Wall Temperature, Deg. Fahr.

Cylinder					
No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
380	400	395	400	390	391

We do not want to convey the impression that equal air-distribution is essential, for usually, when cylinder temperatures are equal, the air distribution is far from equal. We have suffered some very disastrous results on new experimental engines where time was not taken to install thermocouples. Instead, air-flow was adjusted to give equal pitot-tube readings on all cylinders. When the engine was heavily loaded, certain cylinders froze, because of incorrect cooling.

Combustion-Chamber Characteristics

Very little work has been done to improve the shape of the combustion-chamber, since freedom from detonation has been very pleasing. However, experiments with four spark-plugs in each head have conclusively demonstrated that a spark-plug underneath the exhaust valve showed slight improvement in power.

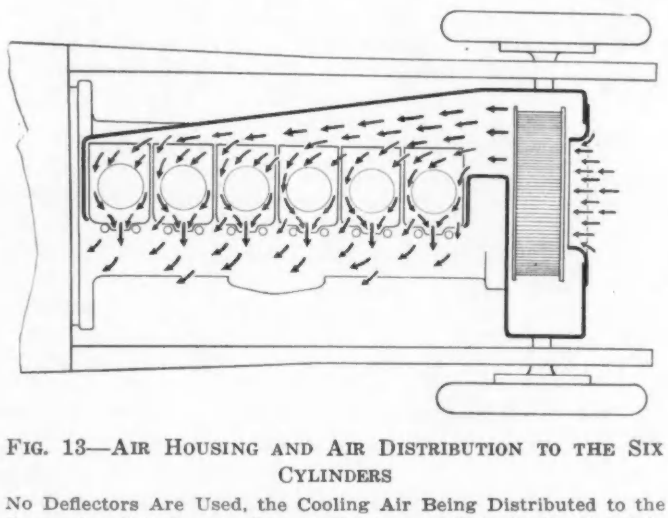

FIG. 13—AIR HOUSING AND AIR DISTRIBUTION TO THE SIX CYLINDERS

No Deflectors Are Used, the Cooling Air Being Distributed to the Successive Cylinders in Correct Volume and Velocity To Maintain Uniform Cooling as a Result of the Shape of the Side Housing

Incidentally, as much power was obtained with one spark-plug as with any combination up to four plugs. Our experience has been that, where more than one plug is necessary, the designer should know conclusively that one plug is poorly located.

With regard to compression ratio, one of our test cars was driven from Colorado Springs, Col., back to the factory in Syracuse, N. Y., with the same compression-ratio as was used in the Pike's Peak tests. This car had an 8.5:1 ratio and worked very satisfactorily with regular ethyl gasoline as bought at roadside filling stations. Although we do not recommend such a ratio, this shows that the combustion-chamber is good as regards detonation characteristics.

Performance of the Present Engine

Fig. 14 shows the output of the present engine as compared with the earlier construction shown in Fig. 1. Both engines have cylinders of 3½-in. bore and 4¾-in. stroke and were tested in exactly the same way. The curves reveal that the present engine develops a continuous brake-horsepower of 87, whereas the earlier powerplant developed 67 b. hp. However, the increase in peak power is perhaps not as interesting as the power at 3500 r.p.m. Here the output is increased from 48.25 to 85 hp., which represents a gain of approximately 76 per cent without a change in piston displacement. This increase in output results from:

(1) Better cooling characteristics of the cylinder
(2) Increased valve-areas
(3) Decrease in power absorbed by the fan
(4) Increased compression-ratio

To evaluate the effect of each change is rather difficult, as the changes are more or less interrelated. However, we are primarily interested in the final result; that is, the highest possible output from a practical engine, one that will withstand abuse and continue to perform day in and day out without constant adjusting.

Our experimental department has subjected this side-draft engine to all sorts of gruelling tests. One engine completed a 500-hr. test at 2000 r.p.m., full throttle, in a dynamometer with air entering the fan at 110 deg. fahr. When torn down for inspection, the engine was found to be in excellent condition; the exhaust valves were black, showing excellent cooling; and the valves were tight and capable of many more hours of operation before regrinding would be necessary. Another engine was operated in the dynamometer room with four other engines as heat generators. Steam was turned on in the radiators to make the room literally an oven. Yet this engine completed a 4-hr. run at 3000 r.p.m., full throttle, with the room temperature and the air entering the engine fan at 165 deg. fahr. It would have continued to run longer if the automatic sprinkler had not opened, flooding the dynamometer room and stopping the engine. This engine, when torn down, was found to be in perfect condition and was promptly reassembled for further testing.

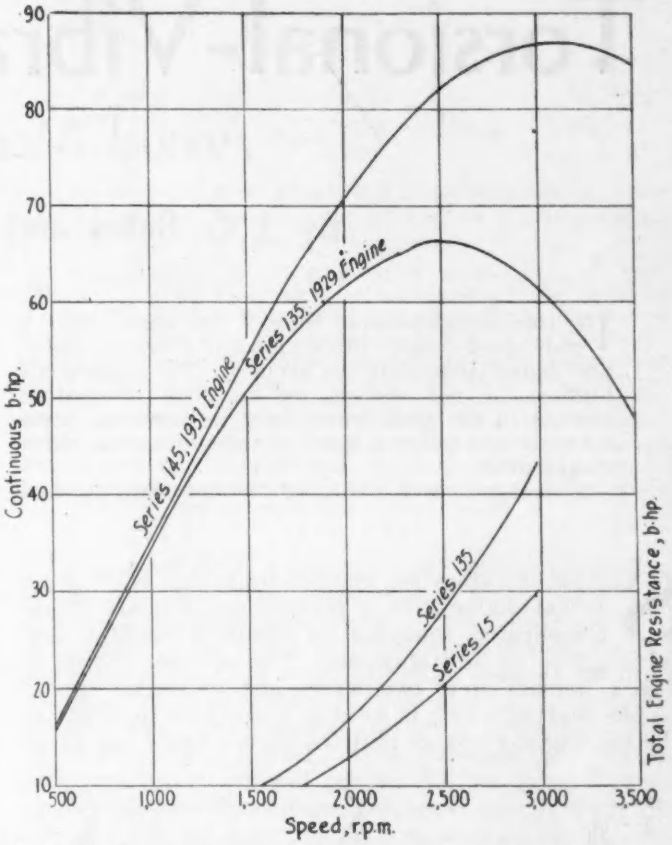

FIG. 14—POWER CURVES OF PRESENT SERIES-15 ENGINE AND SERIES-135 ENGINE

The Upper Two Curves Show the Brake-Horsepower Output Taken under Identical Conditions with Cooling Fan, Generator, Air-Cleaner and Muffler Connected and with Automatic Spark-Advance. The Lower Two Curves Show the Total Engine Resistance, Including Pumping Losses and Power Absorbed by the Fan. Both Engines Operated on Sunoco Blue Gas. Both Engines Have 3½ x 4¾-In. Cylinders and 274-Cu. In. Piston Displacement. The Compression Ratio of Series 135 Is 4.69:1 and That of Series 15 Is 5.30:1

Other engines have been installed in 7-ton Army tanks, which present the hardest service to which an engine can be subjected. The engine in a tank is located in the rear and is enclosed literally in a hot-box, obtaining its supply of cooling air through a small opening in the rear of the tank. It receives no benefit of velocity air-pressure caused by the movement of the vehicle. In spite of the severity of this service, the engine has performed satisfactorily under all conditions.

Torsional-Vibration Dampers

Annual Meeting Paper

By J. G. Baker[1] and J. P. Den Hartog[1]

In internal-combustion engines operating over a wide speed-range, critical speeds of torsional vibration cannot practically be avoided. The ensuing vibrations, if not checked, set up high alternating stresses in the shaft which have in numerous cases led to fatigue failures, many of these occurring in the crankshaft.

Several devices that successfully limit these stresses to safe values during any critical speed have been developed. The fundamentals of torsional vibration and these stress-limiting devices are discussed in this paper. According to the authors, the stresses set up during a critical speed can be calculated in advance. Tests made on a model in the laboratory are described and the results thus obtained prove the methods of calculation to be reliable.

Since the vibration phenomena taking place in an actual engine with or without dampers are rather complicated, studying an idealized machine first is found to be advantageous. The system, shown in Fig. 1, is made up of two discs *a* and *b* mounted rigidly on the shaft *c*, which is fixed at *d* and free to rotate in the bearing *e*. Suppose that the discs *a* and *b* are given

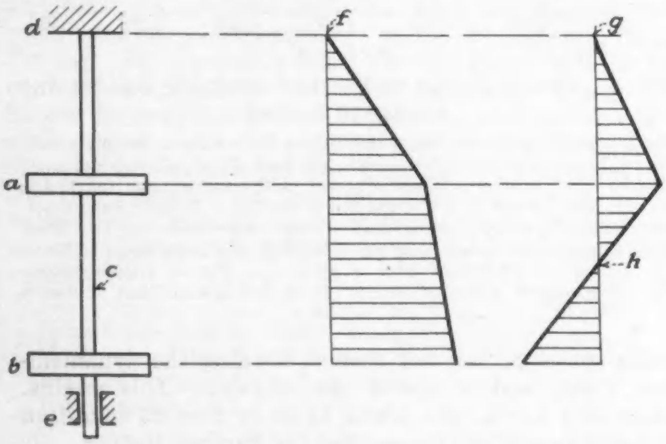

Fig. 1—An Idealized System for Studying Vibration Phenomena

The System Consists of Two Discs *a* and *b* That Are Rigidly Mounted on the Shaft *c*, Which Is Fixed at *d* and Free To Rotate in the Bearing *e*. If the Discs Are Given Small Angular Displacements in a Clockwise Direction and Released, All Parts of the Shaft Will Rotate Back and Forth with the Same Frequency and Exactly in Phase, the Distortion of the Shaft at the Instant When the Motion Is Reversing Being Represented by the Diagram at the Left. If *a* Is Displaced Clockwise and *b* Counter-Clockwise and Then Released, the Distortion of the Shaft When the Motion Is Reversing Will be Represented by the Diagram at the Right

small angular displacements in a clockwise direction and then released. If the ratio of these two initial displacements is properly chosen, on release all portions of the shaft will rotate back and forth with the same frequency and exactly in phase. At an instant when the motion is reversing, the distortion in the shaft is represented by the diagram at the left. If *a* is displaced clockwise and *b* counter-clockwise with the right ratio of displacements and then released, the system will again oscillate in a simple harmonic manner but with a much higher frequency. The discs in this case will always be rotating in opposite directions with respect to each other. The distortion of the shaft at the instant of a reversal in the motion under the latter condition is represented by the diagram at the right. If we choose different ratios between the initial displacements of *a* and *b* than those shown, a combination of the two frequencies and a combination of the two configurations of distortion described will result. Thus we see that each mode of vibration has only *one* frequency. In the configuration represented by the curve at the left one point *f* of the shaft does not move during the vibration, while that represented by the other curve has two such nodes, namely the points *g* and *h*. For this reason the configuration at the left is called the first or fundamental mode of vibration, while that at the right is called the second mode.

Imagine the system to be set vibrating in the funda-

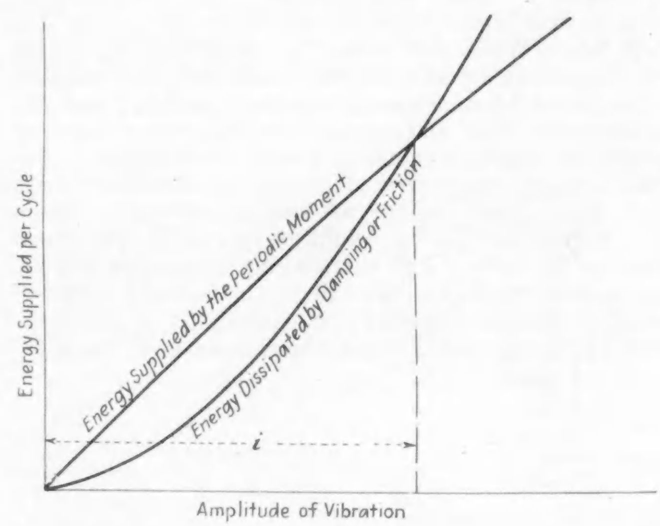

Fig. 2—Energy Relations in a Torsionally Vibrating System

When the Energy Supplied per Cycle by the Periodic Movement Balances That Dissipated by Damping or Friction, the System Will Vibrate with the Amplitude *i*

[1] Research engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

mental mode and then left to its own resources. The vibration will gradually die down since energy is dissipated in the shaft material, the bearings and other parts of the system. The oscillation can be maintained by supplying to the system a quantity of energy equal to that dissipated. Thus, if a small periodic moment is applied to either disc in such a way that it is always acting in the direction of rotation of the disc, vibrations of a considerable amplitude can be maintained. This periodic moment need only be of the same order of magnitude as the damping or friction moment.

Large amplitudes caused by small moments are impossible, except at these natural frequencies. The various factors determining the amplitude of the vibration at a natural frequency are shown in Fig. 2. The curves in this figure show the energy supplied per cycle to the system by the periodic moment plotted against the amplitude of vibration, the slope of this curve being proportional to the magnitude of the periodic moment and the energy dissipated by the damping or friction per cycle. The system will evidently vibrate with the amplitude i at which the two energies balance. If momentarily the magnitude is smaller than i, the input energy is greater than the dissipated, so that the amplitude will increase. Conversely, if it is larger than i, the excess damping energy will decrease the

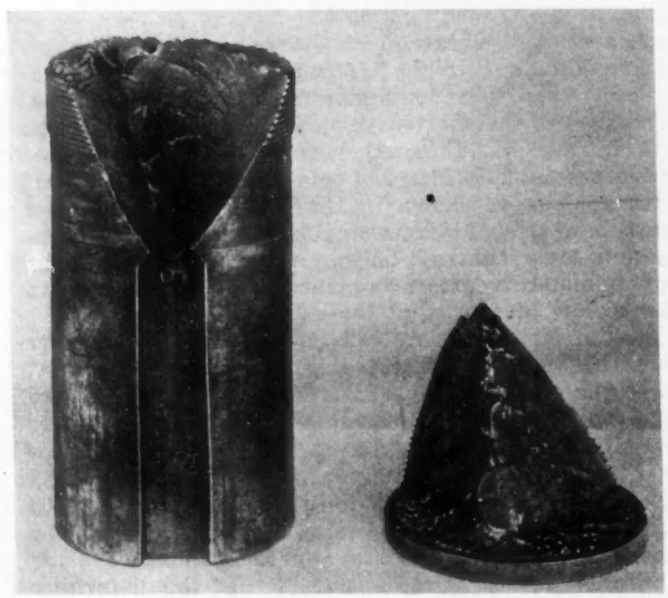

FIG. 3—A TYPICAL EXAMPLE OF A CRANKSHAFT BROKEN BY FATIGUE DUE TO TORSIONAL VIBRATION

amplitude. By changing either the energy-input curve or the damping curve, the balance will occur at a different amplitude.

If the fixed end d, Fig. 1, is replaced by a large flywheel on the shaft, the situation will not be changed appreciably, since the great inertia of the flywheel acts much the same as a fixed end. Consider that this system is kept in a steady state of vibration by a small periodic moment at the natural frequency, and imagine now that the flywheel is rotating at a constant speed. That the rotations of the various shaft cross-sections with respect to each other will be unchanged is apparent. Externally viewed, the discs will appear to rotate with uneven angular-speed, but if riding on the flywheel and observing the system were possible, the discs would be seen to oscillate.

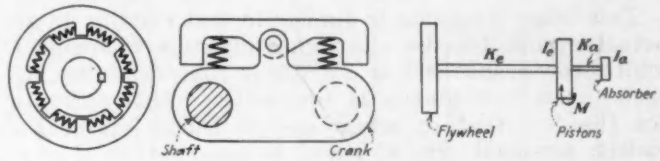

FIG. 4—TWO DYNAMIC-VIBRATION ABSORBERS AND A SCHEMATIC DIAGRAM REPRESENTING AN ENGINE EQUIPPED WITH SUCH AN ABSORBER

The Simplest Form of Absorber, Which Is Shown at the Left Consists of a Flywheel That Is Connected to the Shaft by Springs. In Another Form, Which Is Illustrated in the Central Drawing, a Mass That Is Attached to a Web of the Crankshaft by Springs Constitutes the Absorber. The Effective Inertia of All Crank Thows, Pistons and Other Parts of an Engine Equipped with Such an Absorber Has Been Concentrated into a Single Inertia I_e, While the Effective Crankshaft Flexibility Is Represented by K_e. The Effective Moment Due to Gas Pressures and Other Causes That Maintains the Vibration Is Denoted by M. I_a Represents the Absorber Mass or Flywheel and the Absorber Springs Have a Flexibility of K_a

The crankshaft of a two-cylinder internal-combustion engine with a flywheel behaves very much like a simplified system discussed above. The discs mentioned correspond to the inertias of the crank throws, pistons and other parts. The lengths of shaft between the discs represent the flexibilities of the crankshaft from the center of one crank-throw to the center of the next. For example, a two-cylinder two-stroke-cycle gas-engine, with two power strokes per revolution, runs at 1000 r.p.m. Assume the natural frequency of shaft for the first mode to be 2000 complete oscillations per minute. The engine will then operate at a critical speed. To observe the crankshaft, we choose a point of view on the flywheel. From this point the crank throws will appear to rotate about the axis of the shaft through a small angle, first in one direction and then in the other. Just as they are both turning counter-clockwise, the explosion occurs in No. 1 cylinder, resulting in a force tending to increase the speed of rotation of the throws. Now the throws come to their extreme positions and start back. The force of the explosion is now dissipated and they move back unimpaired and reverse. Again they move counter-clockwise but this time No. 2 cylinder fires and a force is applied to No. 2 crank tending to increase the velocity of the cranks. Thus the variations in torque due to the changing gas pressures supply the necessary energy to maintain the system in a state of vibration.

Such vibrations obviously set up high alternating stresses in the shafts, which may be many times greater than the load torque stresses. Fatigue failures of crankshafts due to this have occurred frequently. Fig. 3 shows a typical fracture of this type. Another interesting example that has recently attracted great attention is the failure of the crankshafts in four out of the five engines in the Graf Zeppelin, the details of which will be discussed later.

External Evidence of Torsional Vibration

In the idealized case of a system of circular discs on a shaft and a flywheel, large torsional vibrations can take place without any reaction whatever on the bearings if the discs are balanced. On the other hand, if the discs are unbalanced, periodic lateral forces will be transmitted from the shaft to the bearings, which will tend to set up secondary vibrations in other parts of the machine.

This latter condition is similar to that existing in an actual engine, because although completely balancing a multithrow crankshaft *as a whole* is possible, balancing each throw individually is impossible. This accounts for the fact that in actual gas or Diesel engines, a violent torsional critical speed is observed as a general vibration and noise about the whole machine.

The Multi-Cylinder Case

In multi-cylinder engines, the conditions are in principle the same as in the simplified scheme of Fig. 1, although they are more complicated. Many critical speeds of more or less importance exist at which the fundamental-mode vibration, at the fundamental frequency, can be excited. Many critical speeds at which the second mode can be excited also exist, although in practice vibrations at the second and higher modes have been found to be of less importance.

By a proper choice of the flexibility of the crankshaft the critical speeds can be sufficiently far removed from the running speed in a constant-speed engine. However, in automobile and other variable-speed engines, obtaining a design without serious critical speeds in the running range is practically impossible.

The longer and more flexible the crankshaft and the larger the variations in torque, the more serious torsional vibration is apt to be. Modern tendencies in automobiles are toward these extremes. Engines are being built with more cylinders in line and using higher compression. The Diesel engine is, of course, the best example of the latter tendency. That these tendencies increase the importance of introducing means for limiting the amount of distortion in the crankshaft during a torsional critical-speed is evident.

[2] See *Transactions of the American Society of Mechanical Engineers*, vol. 50, paper APM-50-7.

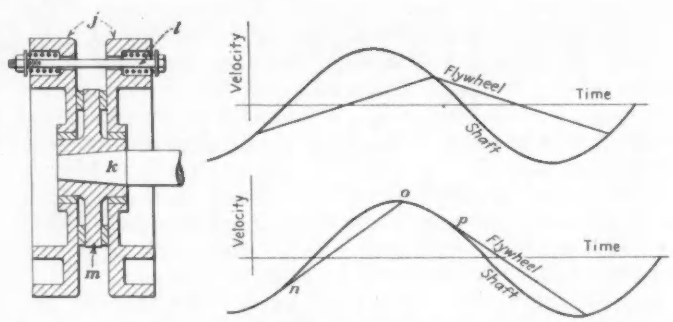

Fig. 6—Lanchester Damper (Left) and Two Velocity-Time Diagrams (Right)

The Function of This Device Is To Decrease the Amplitude of Vibration by Introducing an Additional Energy-Dissipation into the System. In the Upper of the Two Velocity-Time Diagrams, the Damper Flywheels Were Slipping Continuously with Respect to the Crankshaft While in the Lower the Flywheels Slipped Part of the Time and Were Solid on the Crankshaft during the Remainder of the Cycle Due to the Pressure Bolts Being Rather Tight

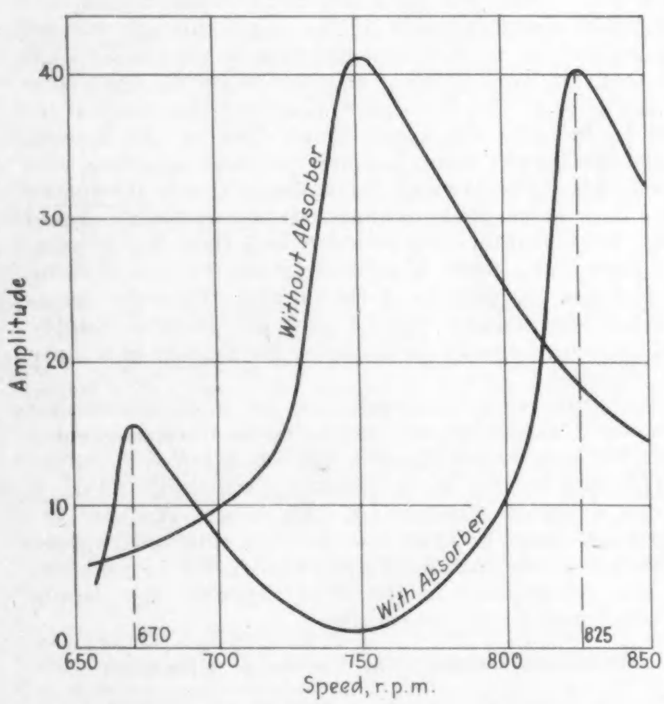

Fig. 5—Test Results Obtained on a Laboratory Model of a Dynamic-Vibration-Absorber System

While the Attachment of the Absorber Practically Eliminated a Very Violent Critical Speed That the Model Originally Had at 750 R.P.M., Critical Vibrations at 670 and 825 R.P.M. Were Introduced, Thus Proving Conclusively That a Simple Dynamic-Vibration Absorber Does Not Improve Conditions When Applied to a Variable-Speed Engine

Dynamic-Vibration Absorber

A torsional vibration in a constant-speed machine can be eliminated by the application of a dynamic-vibration absorber. The simplest form consists of a flywheel connected to the shaft with springs as indicated at the left in Fig. 4. In another form of construction it appears as a mass attached to a web of the crankshaft with springs as shown in the center. The absorber mass is restrained from angular movement with respect to the crankshaft only by the springs. A scheme approximately representing the engine with such an absorber is illustrated at the right.

The effective inertia of all throws, pistons and other parts has been concentrated into a single inertia, I_e, while the effective crankshaft flexibility is represented by K_e. The effective moment M, due to gas pressures and similar causes maintaining the vibration, operates on I_e. The absorber mass or flywheel is I_a, and the absorber springs have a flexibility K_a. For the device to be operative, the absorber mass and springs must be chosen so that the absorber by itself has the same natural frequency as the frequency ω of the disturbing moment, or

$$\omega = \sqrt{(K_a/I_a)} \quad (1)$$

When this is the case, the flywheel I_e practically will not vibrate and the amplitude of vibration of I_a will adjust itself to such a value that the moment exerted on I_e by the absorber spring K_a will be equal and opposite to the disturbing moment[2].

When the frequency of the disturbing force and consequently the speed of the engine is kept constant, an absorber that will operate very successfully can be constructed. Although the vibration is eliminated at exactly the speed for which the absorber is designed, two new critical speeds, one above and one below the original critical speed that was removed, are created by the introduction of the absorber.

Fig. 5 shows some experimental results obtained on a laboratory model of a system resembling that of Fig. 4. The model originally had a very violent critical speed at 750 r.p.m. Attaching the absorber decreased the

vibration at 750 r.p.m. to practically nothing, but instead critical vibrations appeared at 670 and at 825 r.p.m. This test shows conclusively that a simple dynamic absorber does not improve conditions when applied to a variable-speed engine.

The Lanchester Damper

Referring to the curves in Fig. 2, the amplitude of vibration will be diminished by the introduction of additional energy-dissipation into the system, which is the function of the Lanchester damper, illustrated at the left of Fig. 6. The device consists of two flywheels j, which are mounted on the crankshaft k so that they can rotate freely. Pressure bolts and springs l press the flywheels against the disc m that is rigidly attached to the shaft. For better operation some brake-lining or other friction material is inserted between j and m. The damper is placed on the crankshaft at the location where the maximum motion due to torsional vibration is expected, which, in the case of an automobile engine, is at the front.

At or near a torsional critical-speed the shaft k will vibrate torsionally as explained before. The inertia of the flywheels j tends to prevent them from following these vibrations. The energy dissipated in the damper is proportional to the product of the friction torque and the relative motion between the flywheels and the shaft. Therefore no energy dissipation takes place when the damper is either loose or very tight, for in the former case no torque is present and in the latter no relative motion. To know what intermediate friction gives the maximum energy-absorption, the action of the damper must be considered in more detail.

At the right of Fig. 6 are plotted the velocity-time relations of the shaft and of the damper flywheels. The shaft velocity is represented by an approximately sinusoidal curve. While the flywheels are slipping, the frictional torque acting on them is constant, assuming that the friction is independent of the velocity which has been found by experiment to be the case[3]. Consequently the angular acceleration is constant so that the velocity curve must be a straight line, having a slope that is proportional to the friction torque. For rather small values of the torque we have the condition shown in the upper curve where the flywheels are slipping continuously with respect to the shaft. When the pressure bolts are rather tight, the flywheel velocity curve becomes steep and the condition shown in the lower curve, where the flywheels slip part of the time and are solid on the shaft during the remainder, occurs. In the latter curve, between the points n and o, the forward velocity of the shaft is greater than that of the flywheel so that the flywheel is accelerated forward. At the point o, the velocities are equal and they remain so until the point p where the downward slope or acceleration of the shaft becomes sufficient to break the flywheel loose.

[3] See *Transactions of the American Society of Mechanical Engineers*, vol. 52, paper APM-52-13, p. 136.

[4] See *Transactions of the American Society of Mechanical Engineers*, vol. 52, paper APM-52-13, p. 141.

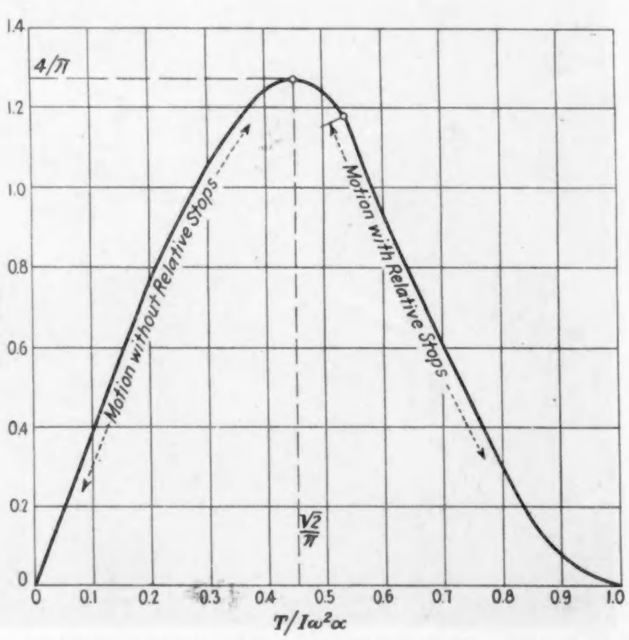

FIG. 7—ENERGY ABSORBED IN THE DAMPER PLOTTED AGAINST FRICTION TORQUE FOR A GIVEN SHAFT VIBRATION

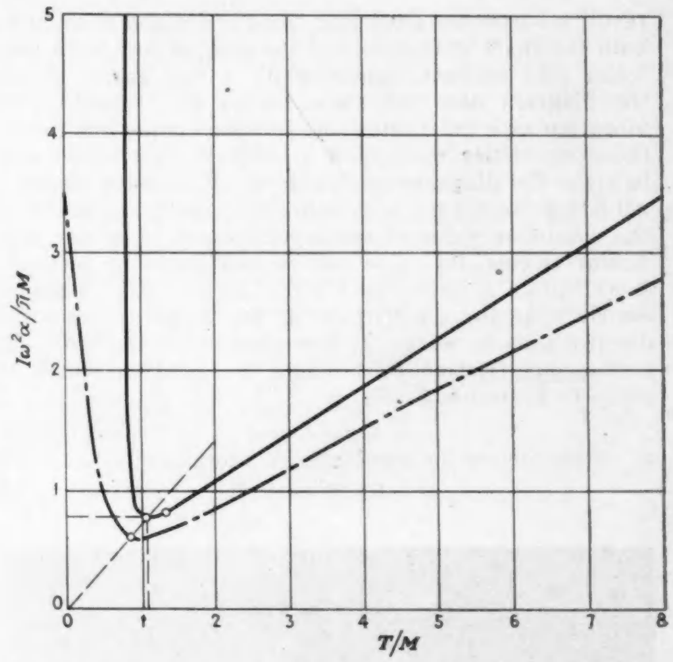

FIG. 8—RESONANT AMPLITUDE PLOTTED AGAINST FRICTION TORQUE

A mathematical analysis[4] of the conditions represented by these curves enables us to arrive at the result pictured in Fig. 7, where the energy dissipated per cycle E is plotted in effect against the friction torque T for a given shaft vibration. Quantitatively the ordinates are not E but rather E divided by the constant $I\alpha^2\omega^2$, where

α = amplitude of vibration of shaft in radians
I = moment of inertia of damper flywheels
$\omega = 2\pi$ times the number of vibrations per second

Similarly the abscissæ are not T but rather T divided by the constant $I\alpha^2\omega^2$. This has the advantage that the diagram holds for all sizes of damper, all frequencies and all amplitudes of vibration.

Equating the input energy to the energy dissipated in the damper, the amplitude of vibration can be calculated with the result shown in the full-line curve of Fig. 8. Since in this case no damping due to internal friction, or hysteresis, in the shaft is considered, the

result is somewhat academic. In the dot and dash curve both the shaft hysteresis and the damper loss have been taken into account, representing a real case. Again the diagram does not show merely the amplitude of vibration as a function of the friction torque but rather these quantities multiplied by certain constants so as to make the diagram applicable to all types of damper. All letters used have been defined except $T_{i\ max}$ which is the maximum value of the input torque. For any particular engine, its value can be calculated by methods described in a paper by F. M. Lewis[5]. Fig. 8 shows clearly that for no friction or for large friction the damper fails to work. It also shows that the most advantageous friction torque has the relation which is given in Equation 2.

$$T = 1.1\, T_{i\ max} \tag{2}$$

at which torque the amplitude of vibration is

$$\alpha = 2.5\, (T_{i\ max}/\omega^2) \tag{3}$$

FIG. 9—MODEL BUILT TO OBTAIN EXPERIMENTAL DATA FOR VERIFICATION OF THE THEORETICAL RESULTS

An important property of the diagram is that the left-hand branch of the curve is very much steeper than the right-hand one. This means that to tighten the damper too little impairs its damping property much more than to tighten it too much. In practice, therefore, the damper should be adjusted somewhat tighter than is indicated by Equation 2.

From Equation 3 we can conclude that the amplitude of vibration is inversely proportional to the moment of inertia of the damper. Thus the heavier the damper flywheels are, the better they work. On the other hand, from Equation 2 we see that the tightening of the pressure springs is independent of the size of the damper. These equations enable us to precalculate the amplitude of torsional vibration at any critical speed for engines equipped with dampers. To be sure of safety of a design, such calculations should be performed in advance.

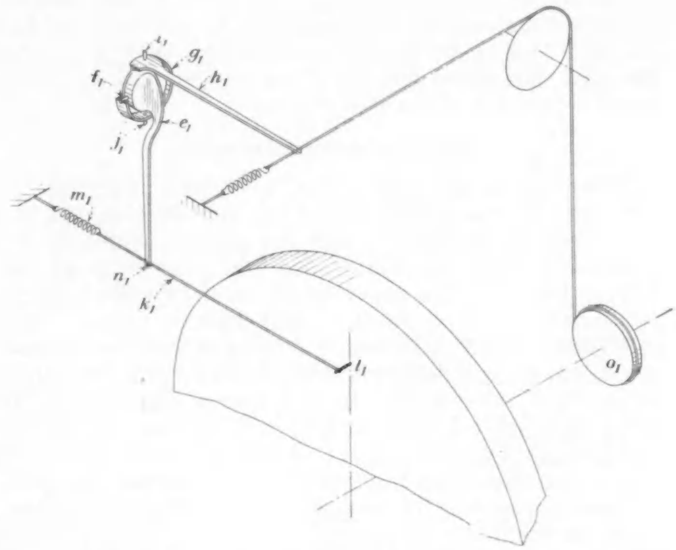

FIG. 10—DETAILS OF THE OPTICAL RECORDING SCHEME USED WITH THE MODEL SHOWN IN FIG. 9

To obtain experimental data primarily for verification of the theoretical results mentioned, a model was built as shown in Fig. 9. A flywheel, Q, and the long

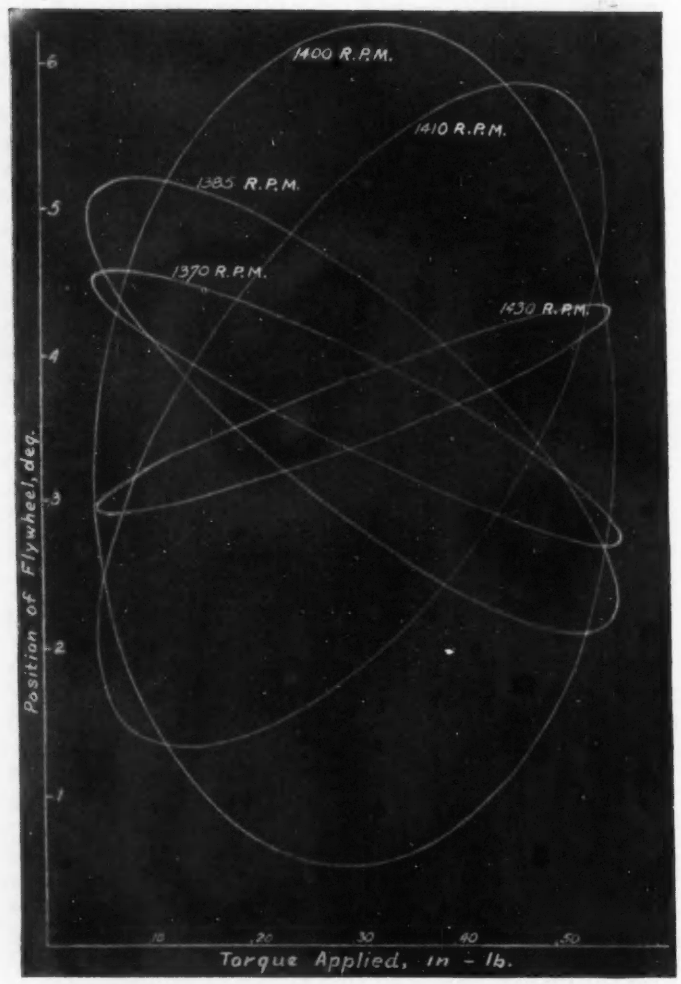

FIG. 11—OPTICAL RECORD OF VIBRATIONS OBTAINED WITH THE DAMPER LOOSE

[5] See *Transactions of the American Society of Naval Architects and Engineers*, vol. 33, p. 109.

shaft R simulate the effective inertia and flexibility respectively of the crankshaft as in Fig. 4. The large flywheel S, Fig. 9, corresponds to the flywheel in an actual engine. The damper T, with the frictional surfaces arranged much as in Fig. 6, is mounted on the flywheel Q, Fig. 9.

The frictional torque between the damper flywheels and the damper hub may be changed by the wing nuts U. On the shaft end is attached a mechanism, the sole purpose of which is to supply a periodic torque to the shaft. In this mechanism an eccentric that is attached to the disc V is connected to the drum W by the steel band X in such a way that when the eccentric is rotated by the motor Y, W oscillates back and forth through an angle of approximately 30 deg. In order that the band X may be always taut, it is continued around the drum and attached to a spring, the end of which is visible at Z. The drum W is connected to the outer end of the coil spring A_1. The oscillation of the drum W twists the coil spring A_1 and thus applies the periodic moment to the system, the frequency depending on the speed that we choose for the motor. This periodic moment acts on the model shaft in the same way that the variations in torque in an internal-combustion engine act on its crankshaft. In order that the movements of the shaft might be studied and measured, they were magnified by using a light beam. The concave mirror B_1 reflects the image of the incandescent light filament C_1 on the screen or photographic plate placed at D_1. Fig. 10 gives a more detailed picture of the mirror arrangement. The part e_1 that carries the mirror is mounted on the pivots f_1 and g_1, which are held in the part h_1 which in turn is pivoted on the stationary pivots i_1 and j_1. The wire k_1 is stretched between a pin attached to l_1 and the spring m_1. At the point n_1 the wire k_1 is fixed to the extreme end of e_1. By these means, angular movement of l_1 causes rotation of the mirror about a horizontal axis. In a similar manner angular movement of the drum o_1 or W_1, Fig. 9, results in the rotation of the mirror about a vertical axis. Thus the mirror is arranged so that when the flywheel l_1, Fig. 10, or S, Fig. 9, is oscillating due to the moment at the left end of the shaft R, the light beam falling on the screen D_1 traces out an approximately elliptical figure. The abscissa of any point of this figure indicates the instantaneous torque acting at the shaft end and the ordinate indicates the instantaneous position of the flywheel Q. The figures described were recorded on a photographic plate, Figs. 11 and 12 being typical records taken in this way. The important thing about any figure is its total height; for the total height is a measure of the amplitude of vibration in the model at the time the figure was recorded.

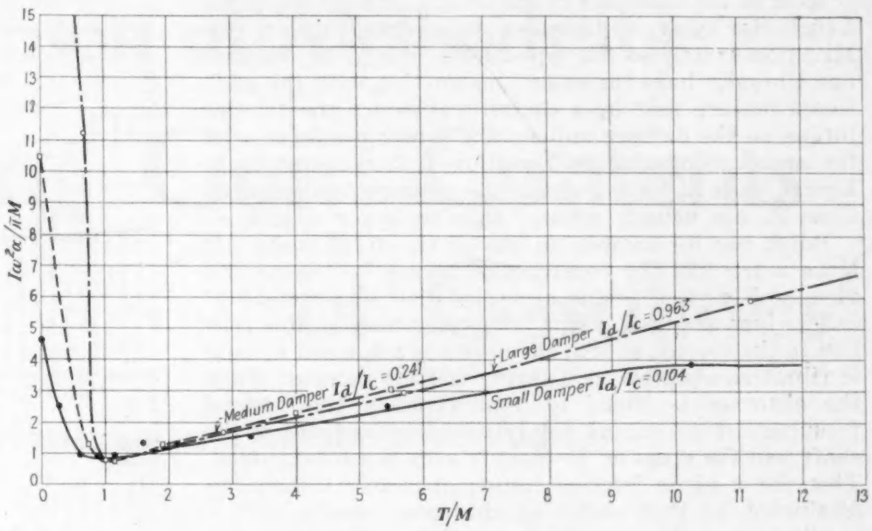

FIG. 13—RESULTS OBTAINED FROM MEASUREMENTS OF THE PHOTOGRAPHIC RECORDS

These Curves Are for Small, Medium and Large Dampers Respectively, the First Being the One of Greatest Practical Value

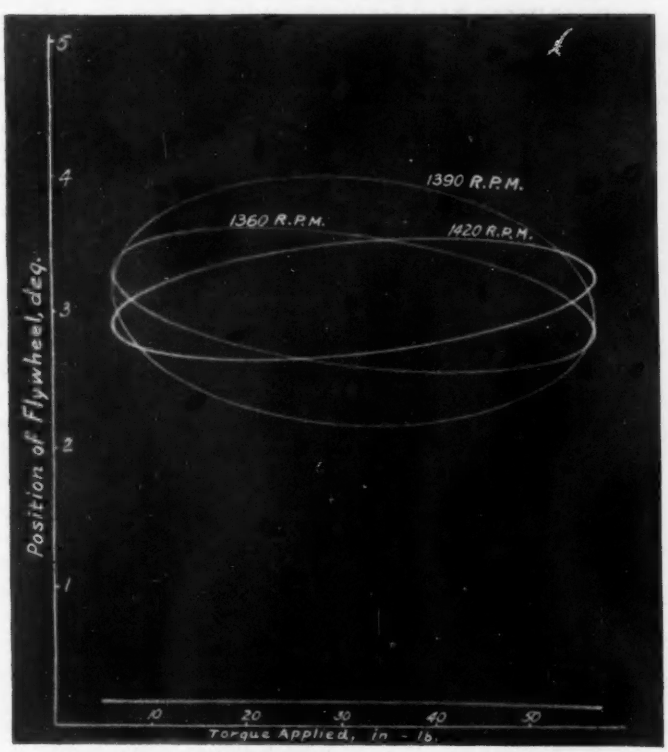

FIG. 12—ANOTHER OPTICAL RECORD OF VIBRATIONS

This Was Made After the Damper Had Been Tightened Properly

Experimental Conditions and Results

The model was operated without the damper and with dampers of various inertias. For each size of damper, many friction torques were used from practically zero up to torques sufficient, in most cases, to carry the damper flywheel continuously without slippage. The figures described were photographed at several speeds of the motor for each setting of the frictional torque. In this way the maximum amplitude and the frequency at which it occurred were found.

The results obtained from the measurements of the photographic records are plotted in Fig. 13. They show very good agreement with the theory. The curve of greatest practical value is that for $I_d/I_c = 0.104$. This represents a ratio of the inertia of the damper to the inertia of the crankshaft, pistons and other parts of about one-tenth which is of the same order as ordinarily used in gas or Diesel engines.

Most of the dampers in use on automobiles are of the Lanchester type. Studebaker, for instance, uses a construction exactly of the type shown in Fig. 6. Packard and Chrysler have the same construction with the additional feature that by a centrifugal device the friction torque on the damper automatically becomes large with the speed. Considering Equation 1, this seems to be logical, since at higher speeds the effective-torque variations T_i are usually greater than at lower speeds.

Buick has its damper on one of the crank webs. It looks much like the construction shown in the central view of Fig. 4, with the exception that leaf instead of coil springs are used. This introduces considerable friction in the system, so that the device is a damped dynamic vibration-absorber or a spring-friction damper. When the absorber is tuned to approximately the natural frequency of the engine, the relative motion between the shaft and the mass or flywheel is very much magnified. This, for a given friction torque, increases the energy dissipated, so that obtaining the same results with a smaller mass than would be needed without springs seems possible. This statement is as yet a theoretical result and has not been checked by experiment to the best of our knowledge.

The Case of the Graf Zeppelin

As was mentioned before, the Graf Zeppelin, on starting from Europe for the United States in May, 1929, was forced to return due to failures in the crankshafts of four of its five engines. The cause for these failures has been investigated thoroughly in Germany and all the results have been published[6]. Fig. 14 is a schematic drawing of the installation with the amplitude diagrams of the fundamental and second modes of natural torsional-vibration. The engine is a 12-cylinder V-type with a damper on the front end of the crankshaft. Between the engine and the propeller an extremely flexible coupling is placed. The installation is supposed to run between 1320 and 1450 r.p.m. The investigation showed that when the ship was first used in 1928, the second mode of vibration had a critical speed at 1390 r.p.m. This condition was not sufficiently severe to cause failure, since as was remarked before, a second mode is in most cases far less dangerous than a fundamental. The flexible coupling was arranged so that its torsional flexibility could be changed by the insertion of washers.

In overhauling the engines before the fatal trip this was done but unfortunately in such a manner as to bring the fundamental as well as the second mode to a critical speed around 1400 r.p.m. The vibration in either mode by itself would not break the shaft, but the combination proved to be too much. The cure consisted in putting in another flexible coupling, which threw the fundamental mode out of resonance. Also

[6] See *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, September, 1929, p. 465.

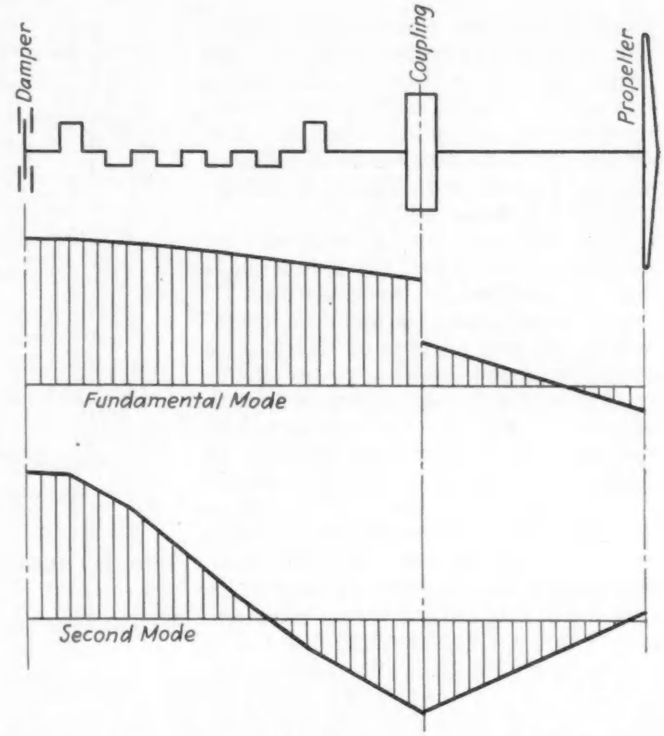

FIG. 14—VIBRATION CHARACTERISTICS OF AN ENGINE OF THE GRAF ZEPPELIN

At the Top Is a Schematic Drawing Showing the Installation of an Extremely Flexible Coupling between the 12-Cylinder V-Type Engine and Its Propeller. The Diagrams Below Show the Amplitude of the Fundamental and Secondary Modes of Natural Torsional-Vibration

some mass was added to one of the halves of the coupling, throwing the second mode out of resonance. The damper was investigated and found to be operating correctly. Without the damper, the shaft stresses were found to be 2.7 times as large as with the damper for the fundamental mode and 1.4 times as large for the second mode. This difference can be explained by the fact that for the same motion at the damper the stresses in the second mode are much higher than in the fundamental.

From this case the conclusion is drawn that the indiscriminate use of dampers without an analysis of the system does not prevent failures. In this particular case where the engine is designed for a rather narrow speed-range, a damper is absolutely unnecessary and only adds to the weight and cost of the installation. In cases where the speed range is very wide, making this entire range free of critical speeds is sometimes impractical or even impossible. Then a damper should be used, and it should be made sufficiently large to make continuous operation at any critical speed a safe proposition.

A Comparison of Methods for Determining Gum Contents of Gasolines[1]

Annual Meeting Paper

By Oscar C. Bridgeman[2] and Elizabeth W. Aldrich[3]

THE OIL REFINER has met the demand for a large supply of high-antiknock gasoline by the development of cracking processes. Unfortunately, cracked gasolines usually contain gummy materials, which may be deposited in the manifold or on the intake valves of automobiles in sufficient quantities to interfere with the proper functioning of the engine. To avoid trouble from this source, refiners remove most of the gum from their product before it is marketed. However, this treatment does not entirely overcome the difficulty, since, due to instability, injurious amounts of gum may be formed during storage.

In order to ensure to Government institutions that the gasoline that they obtain for use in airplanes will not give trouble from gum deposition, a limit was set for the permissible amount of gum as measured by a test devised for this purpose. It has been shown that this method measures not only the gum in the gasoline at the time of test but also some of gum which may be formed on storage. It is now generally believed that two test methods should be developed to take the place of this one, the first to measure the amount of gum present in the gasoline, the second to measure the amount which will be formed on storage. At the request of the Army Air Corps, the Bureau of Standards has made a study of a number of the methods which have been proposed for the first purpose. Since none of those studied appears to be completely satisfactory, further work is being done in order to obtain a more suitable method.

IT FREQUENTLY happens that the solution of one problem is accompanied by the introduction of another equally difficult problem. Thus the widespread adoption of cracking processes to furnish an adequate supply of high-antiknock-value gasoline has introduced the problem of gum, which was largely unknown when all gasolines were straight-run. The problem is a very serious one, for attempts to increase the antiknock value of gasolines by more intensive cracking normally result in the formation of larger quantities of gum, most of which must be removed before the finished product is used in the engine. Fortunately, the majority of refiners go to considerable trouble to keep the gum content of their commercial product within reasonable limits at the time it leaves the refinery. However, it is the gum content of the gasoline at the time it is used which is of importance, and gasolines vary greatly in their tendency to form gum during storage.

Much confusion exists regarding gum in gasoline and it therefore seems advisable to define the terms which will be used in this paper and to analyze the general gum problem. For practical purposes, gum is the material dissolved in gasoline which appears as residue on evaporation. The true gum-content is the amount of material, by weight, dissolved in a given volume of gasoline, which would remain as residue on instantaneous evaporation. In practice, however, varying amounts of residue are formed from the same gasoline, depending on the experimental conditions during evaporation. Each set of experimental conditions gives a residue indicative of an apparent gum-content which represents the true gum-content plus any gum formed during the evaporation process. The true gum-content may change during storage. The gum formed either during storage or during evaporation may be called potential gum, which can be defined as the increase in the true gum-content over any given time-interval under specified conditions. Potential gum is, therefore, a function of the composition of the gasoline, time, temperature and various environmental factors.

Hereafter in this report it will be understood that the term "gum content" refers to the apparent gum-content. Whenever reference is made to the true value of the gum content, it will be so stated.

The problem of gum in gasoline divides itself naturally into three distinct phases:

(1) The development of a suitable method for the determination of the gum contents of gasolines at the time of test

(2) The formulation of a method or methods for predicting the gum contents of gasolines stored for given time-intervals under specified conditions

(3) The correlation of data obtained by the methods developed in the first two phases with the results of engine tests

Solution of the first phase must necessarily precede a

[1] Publication approved by the Director of the Bureau of Standards, Department of Commerce.

[2] S.M.S.A.E.—Research associate, Bureau of Standards, City of Washington.

[3] Junior chemist, Bureau of Standards, City of Washington.

study of the other two, although engine tests are the ultimate criterion of the satisfactory nature of the test method developed. Up to the present time, none of the proposed methods for the determination of the gum content of gasoline has been proved satisfactory. Accordingly, the present investigation was initiated by a study of the first phase outlined above and the present paper deals exclusively with this phase. Comparative data are given on a variety of gasolines by a number of methods. While this work has not been completed, sufficient information has been obtained to permit an analysis of the variables involved and has suggested methods of attack which should lead to a more complete understanding of the problem.

Previous Work

Several methods have been proposed for the determination of the gum contents of gasolines. One of the oldest of these is the so-called "copper-dish method," which has been used for many years as a test in connection with United States Government Specifications for aviation gasolines[4]. This method consists in evaporating to constant weight a measured quantity of gasoline in a copper dish on a steam bath. A number of modifications of the method have been introduced by various investigators, such as the substitution of an iron, porcelain, glass or silica dish in place of the copper dish.

A second method that has been used quite extensively is the "steam-oven method" of Cooke[5], in which the gasoline is evaporated to dryness in a porcelain, glass or silica dish in an atmosphere of slightly superheated steam, followed by drying to constant weight in air in an electric oven. Modifications in procedure have been introduced involving the use of different temperatures in the steam oven, and in some cases the subsequent drying in an air oven has been omitted.

A third method, designated by the term "air-jet," has been proposed recently by Hunn, Fischer and Blackwood[6]. This involves the use of a jet to blow a current of air over the surface of the gasoline in order to accelerate evaporation from a porcelain or glass dish on an open steam-bath.

Comparative data on the same fuels by these methods, or modifications of them, have been obtained by several investigators. Vorhees and Eisinger[7], and also Herthel and Apgar[8], recently made comparisons between the gum contents of a large number of samples by evaporation according to the copper-dish and the steam-oven methods. They maintained the steam oven however at approximately 335 deg. fahr. rather than at a temperature slightly above 212 deg. fahr. as in the original method of Cooke. In general, the copper-dish values were considerably higher than the modified steam-oven values, although Herthel and Apgar give two examples where there is a very marked reversal. Cooke[5] reported data on four samples by evaporation in glass dishes in the steam oven and on the steam bath which roughly agreed with one another, although there was a definite indication that the steam-oven method gave lower results. Hunn, Fischer and Blackwood[6] made measurements on a large group of gasolines by evaporation in copper dishes, in porcelain dishes and by the air-jet method. In general, the copper-dish values were very much higher than those by the other two methods. In about one-half the cases the results by the glass-dish and air-jet methods were of the same general order of magnitude, while in the remainder the air-jet values were distinctly lower.

The published data appear to be quite inconclusive in establishing whether any of the above methods or their modifications are satisfactory for the determination of true gum-content. Very little information is given regarding the reproducibility of the methods, although there seems to be a rather widespread feeling that variations in duplicate determinations by the copper-dish method are liable to be large, whereas the variations are considered to be much smaller by the other methods. There is also considerable doubt regarding the extent to which the samples were heated to "constant weight" after evaporation. Further, the criterion of a satisfactory method which appears to have been adopted is the assumption that the method which gives the lowest gum values is the most significant. While this assumption is somewhat rational, it is not definitive, for there is no assurance that further work might not develop a method giving still lower values for the gum content. The present work was undertaken in order to apply to various methods a more rational criterion for their accuracy as gum tests and to amass further information regarding the reproducibility of these methods.

It is not practicable in the present case to use the test for accuracy employed in quantitative analysis; namely, the preparation of solutions of known concentration. The difficulties inherent in isolating gums and in preventing changes in chemical structure are not easily overcome, and the probable complexity of chemical composition of most gums would necessitate the extraction of gum samples from gasolines prepared by a large variety of cracking processes. A corollary from the general principle of quantitative analysis suggested itself, however, as a possible criterion for accuracy, to the effect that, for any accurate gum-content method, the value obtained for a 50-per cent blend with a gum-free gasoline should be one-half that for the original sample. Although this is a necessary condition for accuracy, it is not necessarily a sufficient condition. On the other hand, it seems improbable that catalysis and oxidation, if operative in the particular method, would exert one-half the effect on the blends as on the original samples in a large group of cases. Accordingly, the establishment of the 50-per cent relation between the values for the blend and the unblended gasoline was tentatively accepted as a sufficient criterion of accuracy for the present purpose.

Preliminary Comparison of Methods

For the first series of comparisons, three methods were employed, namely, the copper-dish, glass-dish and air-jet. Detailed descriptions of these methods follow.

The procedure used in the copper-dish method is that described in method 530.1 of Bureau of Mines Technical Paper 323B. The method consists of evaporating to dryness on a steam bath 100 ml. of gasoline in a clean, previously weighed copper dish. In the present work dryness was interpreted as meaning constant weight; so that after apparent dryness had been reached, the dishes were heated again for successive 2-hr. periods

[4] See Bureau of Mines Technical Paper 322B, 96, 1927.

[5] See Bureau of Mines Reports of Investigations No. 2686, 1925.

[6] See S.A.E. JOURNAL, January, 1930, p. 31.

[7] See *American Petroleum Institute Bulletin*, vol. 10, sec. 2, 1929, p. 169.

[8] See *American Petroleum Institute Bulletin*, vol. 11, sec. 3, 1930, p. 124.

until the weight remained constant to 1 mg.

In the glass-dish method 50 ml. of gasoline was evaporated to apparent dryness on the steam bath in flat-bottomed pyrex evaporating dishes approximately 80 mm. in diameter and 45 mm. in depth. After apparent dryness had been reached, the dishes were transferred to an air oven held at 102 deg. cent. (216 deg. fahr.) and heated to constant weight.

The air-jet method differed from the glass-dish method only in that evaporation was accelerated by a vertical jet of air at room temperature, flowing at a rate of approximately 300 ml. per sec. The air was filtered to remove dust particles by passage through a

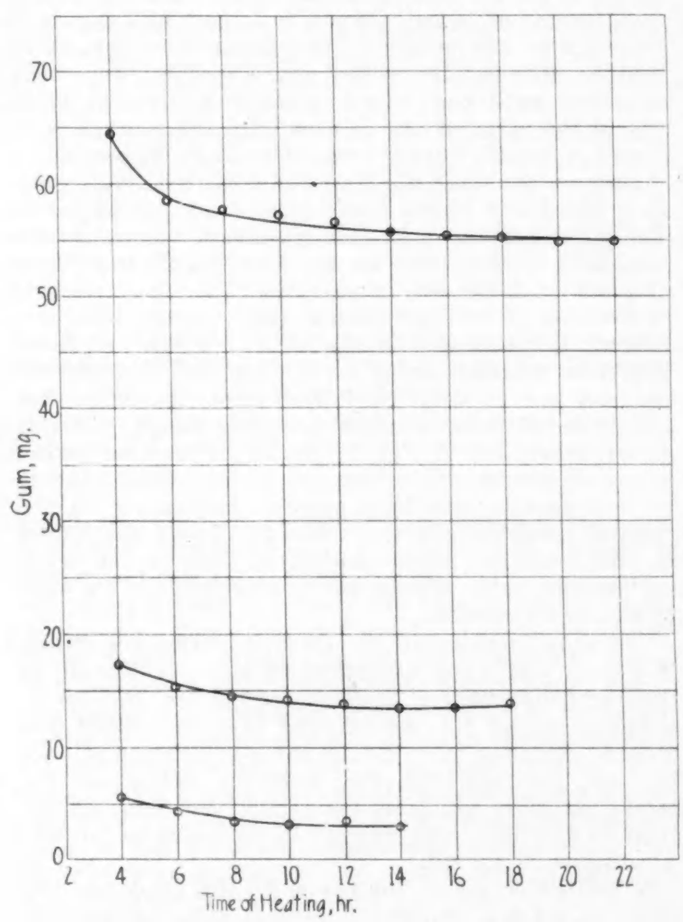

FIG. 1—CHANGE IN WEIGHT OF RESIDUE WITH TIME OF HEATING

tower packed alternately with fine-mesh copper screens and absorbent cotton. The jet consisted of a plain-glass tube of 8 mm. inside diameter, the end of which was approximately 2.5 cm. above the center of the original surface of the liquid.

In all cases the dishes were cleaned with meticulous care. Any gum left from previous determinations was softened and dissolved by means of chloroform, after which the dishes were scrubbed with soap and water. The inner surfaces of the copper dishes were polished with steel wool, and the outer surfaces were carefully cleaned but not burnished. They were then dried with a cloth, placed in a desiccator for ½ hr. and weighed to 0.1 mg. After preliminary cleaning with chloroform and soap and water, the glass dishes were treated with a solution of potassium dichromate and sulphuric acid at room temperature, rinsed with tap water and finally with distilled water. They were then dried with a lint-free cloth, placed in an air oven at 102 deg. cent. for 15 min., allowed to cool in a desiccator for 20 min. and weighed to 0.1 mg.

The gasolines were measured with carefully cleaned dry pipettes, no two gasolines being measured in the same pipette without intermediate cleaning. All dishes after cleaning were handled with crucible tongs with jaws sufficiently wide to encircle the dish and specially fitted with cork tips.

Each test was run in duplicate at the same time and all comparative tests on each sample of gasoline were run on the same day. If there was any difference in the time required to bring duplicate samples to apparent dryness, both were left on the steam bath until the one requiring the longer time had satisfied the conditions for apparent dryness.

The time necessary to evaporate the gasoline to apparent dryness by the three methods differed greatly. Using a copper dish, 4 to 10 hr. was usually necessary to evaporate 100 ml. of gasoline. In the glass-dish method, 50 ml. reached apparent dryness in from 2 to 5 hr.; while, by evaporation under a jet of air, this time was decreased so that from 10 to 60 min. was required.

In accordance with the criterion previously mentioned as a test for accuracy of method, determinations were made by each method on a 50-per cent blend of every sample with a gum-free gasoline. The latter was a freshly distilled Domestic Aviation Gasoline on which blank runs were made to verify the absence of gum.

The technique employed in bringing the dishes to constant weight consisted in successive 2-hr. periods of heating, followed by a 20-min. period of cooling in a desiccator and then weighing to 0.1 mg. until the weight after such procedure remained constant to 1 mg. in the case of gasolines of high gum-content and to 0.5 mg. in the case of those having a low gum-content.

It was found that heating to constant weight within the limits mentioned was a very laborious procedure and required, on the average, from 12 to 16 hr. of heating. Examples of the change in weight with the time of heating are shown graphically in Fig. 1 for three fuels evaporated by the air-jet method, in which the dishes were heated until the weight became constant within the error of the balance. The time of heating required in order to bring the dishes to constant weight within 1.0 or 0.5 mg. according to the gum content was as follows:

Copper Dish, hr.	5 to 29
Glass Dish, hr.	5 to 22
Air Jet, hr.	3 to 16

In some of the later tests a more rigid specification of constant weight was employed.

Data on 20 gasolines and 50-per cent blends by the three methods are given in Table 1. The results are expressed for comparability as milligrams of gum per 100 ml. of gasoline. The lower row of figures for each gasoline are the data on the blends. The average percentage and the actual deviations between duplicates are given in Table 2. Whereas, on the percentage basis, there is not much difference between the reproducibilities, the actual deviations indicate that the air-jet and glass-dish methods give much more reproducible results than the copper-dish method, and the air-jet method gives slightly more reproducible results than the glass-dish method.

The values obtained by the copper-dish method are, on the average, very much higher than those by the other two methods. For gasolines with high gum-content, the glass-dish method seems to give higher results than does the air jet, while for those of low gum-content the two methods give essentially the same values. There does not appear to be any relationship between the results obtained by the three methods. A more legitimate comparison could have been made if 50 ml. of gasoline had been evaporated in the copper-dish determinations rather than 100 ml.

A comparison of the values on the 50-per cent blends by the copper-dish method with the corresponding values on the original fuels shows that the 50-per cent blends in general give a value much less than one-half that on the original sample and, further, that there is no apparent relation between the two sets of values. With the glass-dish method there is more evidence of a relation between the results on the original samples and on the blends, although in this case also the values

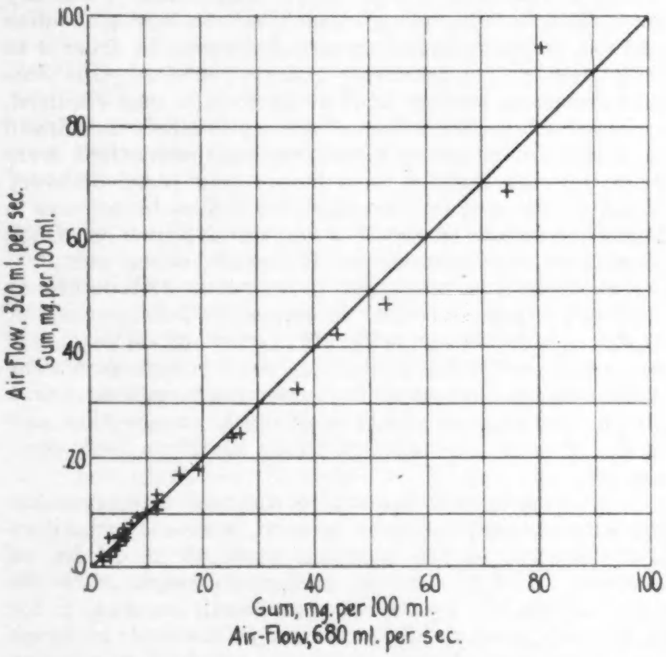

Fig. 2—Gum Obtained by Air-Jet Method, Using Air-Flow Rates of 320 and 680 Ml. per Sec.

The Good Agreement of the Data Indicates the Negligible Effect of the Rate of Air-Flow over This Range

on the blends are less than one-half of those on the original samples. Only in the case of the air-jet method is there, on the average, an approximation to a 50-per cent quantitative relation.

Study of the Air-Jet Method

Since the data given in the preceding section indicate that the copper-dish method is not sufficiently reproducible and is far from satisfying the 50-per cent relation, no further work was done by this method. However, it seemed worth while to investigate further the air-jet method, particularly the effect of variations in air-flow on the results obtained. Accordingly, an additional series of comparative tests was made using three different air-flows; namely, 0, 320 and 680 ml. per sec. The first of these, with zero air-flow, is identical with the glass-dish method mentioned previously in this paper. In the other two cases, control and measurement of the air-flow were effected by means of an orifice meter. The jet consisted of a straight glass tube 12 mm. in diameter, which was used in order to obtain an increased air-flow. Since the main function of the air jet is to facilitate the removal of the gasoline vapors, the size of jet for a given air-flow should not have any appreciable effect.

In these experiments a somewhat more rigorous definition of evaporation to constant weight was employed. After the gasolines had been evaporated to apparent dryness on the steam bath, the dishes were placed in the air oven at 102 deg. cent. (216 deg. fahr.) for a period of 16 hr., after which they were cooled in a desiccator and weighed. Successive 2-hr. periods of heating, followed by cooling and weighing, were then employed until the weight reached a constant value within the error of the balance. On the average, constancy of weight was obtained after 22 hr. of heating.

Data on the three air-flows were secured on 13 gasolines and their 50-per cent blends, and are shown in Table 3. For the high-gum gasolines, values by the glass-dish method (zero air-flow) are higher than those obtained with the two other rates of air-flow, whereas in the case of low gum-content there is very little difference between the results of any of the methods. The data obtained using air-flows of 320 and 680 ml. per sec. are in very good agreement, indicating the negligible effect of air-flow over this range. This is shown graphically in Fig. 2. As in the previous series, values on the blends by the glass-dish method tend to be considerably less than one-half the values on the original samples. In the other two cases the values on the blends are about one-half of those on the original samples, with slightly better agreement in the case of the larger air-flow.

The data in this and the previous series are shown in Fig. 3, where the milligrams of gum per 100 ml. in the blend are plotted against one-half of the corresponding values for the original samples. While the average deviation from the 50-per cent relation is only 2.6 mg., the plot indicates that the values on the blends are more nearly 45 per cent of the value on the original gasoline. The average deviation from the latter relation is 1.8 mg.

A limited series of further tests was made on the effect of air-flow employing various rates of air-flow from zero up to 900 ml. per sec. The results are shown in Fig. 4. It is noted that the values decrease rapidly down to an air-flow of about 300 ml. per sec. and that beyond that point there is very little change in the results. There appears to be a slight indication, however, that the values go through a minimum and tend to increase again. This effect could not be investigated further, since 900 ml. per sec. represents at least the maximum air-flow which can be employed, without danger of blowing some of the gasoline out of the dish with the design of jet used and with a fixed position of 2.5 cm. above the original surface of the gasoline.

From the data recorded in Tables 1 and 3, it appears that, of the methods investigated, the air-jet method with an air-flow of 300 to 700 ml. per sec. is the one which gives the lowest gum-content and is the one which most nearly satisfies the quantitative relation as regards 50-per cent blends with a gum-free gasoline. Littlejohn, Thomas and Thompson[9] have also

[9] See *Journal of the Institute of Petroleum Technologists*, vol. 16, 1930, p. 684.

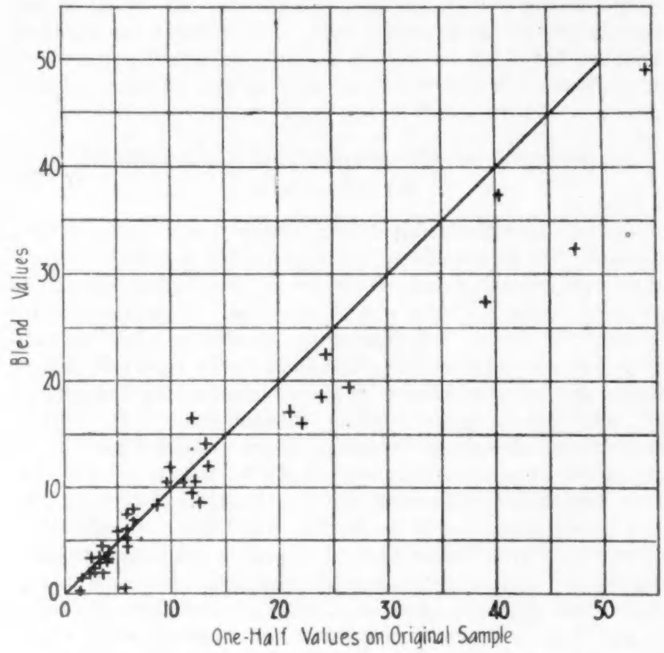

FIG. 3—DATA FROM 50-PER CENT BLENDS WITH A GUM-FREE GASOLINE PLOTTED AGAINST ONE-HALF THE VALUES FROM THE ORIGINAL SAMPLES

The Chart Indicates That the Values on the Blends Are More Nearly 45 Per Cent of Those on the Original Samples than 50 Per Cent

investigated the air-jet method and standardized upon a definite procedure. However, they have chosen a smaller air-flow for the test method.

No experiments were made in this investigation on the effect of using an inert gas in place of air in the air-jet method. Hunn, Fischer and Blackwood[10] found that the results using carbon dioxide or nitrogen are in agreement with those obtained when air is employed.

There is a further test for a quantitative method based on the closeness with which the gum content of a known blend of two gasolines containing gum approximates the value computed from the measured gum-contents of the gasolines themselves. Accordingly, this criterion was applied to the air-jet method and data were obtained on nine pairs of gasolines. These values are shown in Table 4. In each case, the gasolines were blended in equal parts by volume. It is seen that the calculated values are in fair agreement with the observed values.

TABLE 2—AVERAGE DEVIATIONS BETWEEN DUPLICATE DETERMINATIONS

Method	Average Deviation, Per Cent	Average Absolute Deviation, Mg.
Copper-Dish	22.5	23.8[a]
Glass-Dish	13.0	2.5
Air-Jet	13.2	1.7

[a]Excluding the worst three cases, the average absolute deviation is 12.9 mg.

Effect of Atmosphere on Gum Content

The generally accepted theory for gum formation in gasolines involves the assumption that gum is the re-

[10] See S.A.E. JOURNAL, January, 1930, p. 31.

TABLE 1—COMPARISON OF GUM CONTENT DATA OBTAINED BY VARIOUS METHODS

Sample	Method: Copper-Dish		Glass-Dish		Air-Jet	
	Milligrams of Gum per 100 Ml. of Gasoline					
D	815	836	68	75	19	20
Blend	289	297	33	35	10	11
E	361	412	17	18	8	8
Blend	23	32	9		4	4
F	92	93	18	24	12	12
Blend	39	48	6	9	7	8
G	601	663	59	70	15	11
Blend	147	193	17	18	8	8
H	283	308	81	82	70	87
Blend	95	119	28	28	25	30
I	147	132	32	34	25	28
Blend	36	39	15	13	15	13
J	212	221	70		46	51
Blend	53	51	23	28	24	21
K	383	227	19	17	6	5
Blend	116	95	10	6	2	2
L	189	180	13	16	7	8
Blend	23	26	7	7	3	3
M	424	282	9	7	4	8
Blend	19	18	6	5	3	3
N	6	6	4	4	3	3
Blend	8	3	0	3	0	0
O	40	32	18	17	8	6
Blend	9	10	8	8	3	4
P	98	76	20	22	12	11
Blend	24	30	9	9	1	1
Q	31	23	25	23	17	18
Blend	7	5	8	8	9	8
R	16	17	21	21	20	20
Blend	15	7	7	7	12	12
R_1	38	49	35	32	12	11
Blend	16	18	16	14	6	6
T	73	194	36	42	24	24
Blend	32	58	14	14	18	15
U	75		22	22	24	21
Blend	18	14	11	10	10	11
V	699	714	310	310	109	
Blend	239	194	84	95	50	49
W	503	517	65	76	8	7
Blend	105	97	7	6	1	2

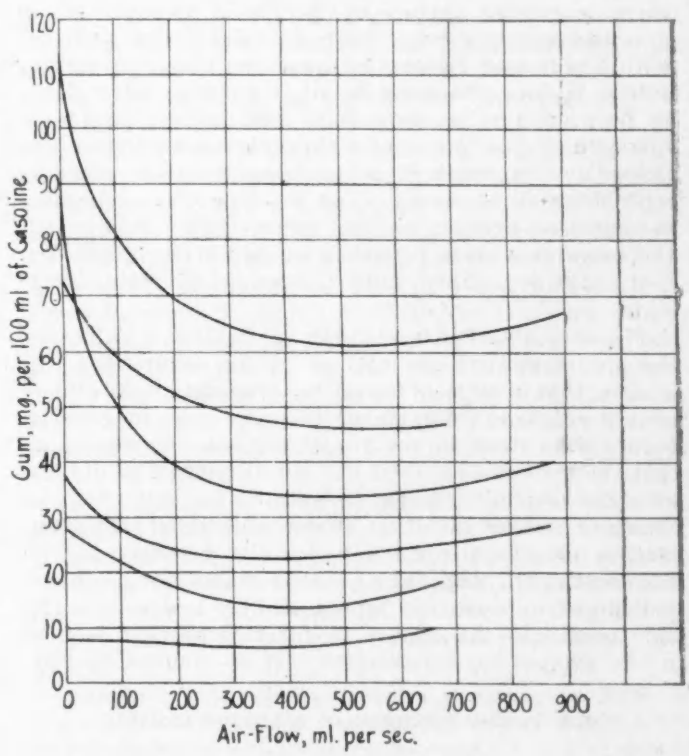

FIG. 4—EFFECT ON GUM CONTENT OF VARIATION IN RATE OF AIR-FLOW USED IN THE AIR-JET METHOD

The Curves Are Plotted from Data on Six Different Gasolines and the Air-Force Rates Ranged from Zero to 900 Ml. per Sec.

TABLE 3—COMPARISON OF DATA OBTAINED USING DIFFERENT RATES OF AIR-FLOW

Sample	Zero Ml. per Sec.		320 Ml. per Sec.		680 Ml. per Sec.	
	Milligrams of Gum per 100 Ml. of Gasoline					
1	16	16	14	13	12	12
Blend	7	7	7	7	6	6
2	4	4	4	4	4	5
Blend	2	4	2	2	2	2
3	4	6	6	4	5	5
Blend	2	2	2	2	4	3
4	29		10		10	10
Blend	12	12	6	6	6	
5	178	163	93	96	81	
Blend	52	50	33	32	38	37
6	9	9	13	11	11	13
Blend	4	5	4	5	4	6
7	2	2	4	3	5	6
Blend	1	1	2	1	3	2
8	42	48	25	24	26	28
Blend	16	19	10	11	12	12
9	276	222	44	52	53	
Blend	71	86	18	19	20	19
10	24	20	23	25	27	24
Blend	7	9	9	10	8	9
11	11	12	8	8	8	7
Blend	5	4	4	3	5	4
12	130	149	41	44	46	43
Blend	29	27	16	18	14	18
13	314	286	164	154	166	
Blend	106		67	70	75	

sult of partial oxidation and polymerization of unsaturated hydrocarbons present in the gasoline. From this standpoint, it seems reasonable to assume that the replacement of oxygen by an inert atmosphere might tend to reduce gum formation during evaporation. As a preliminary test of this assumption, a few experiments were made in which gasolines were evaporated in atmospheres of carbon dioxide or nitrogen. Special evaporation containers were constructed from 100-ml. Florence flasks. The neck was drawn down, and into this was sealed an inlet tube with the opening about 2 cm. above the surface of the liquid when 50 ml. of gasoline was present. Each container was provided with a side arm leading to a vacuum line. In making a test, flasks containing 50 ml. of gasoline were placed in position on the steam bath and carbon dioxide or nitrogen was led into them through a needle-valve and passed out at one-half atmosphere pressure, carrying with it gasoline vapors. The gasoline was evaporated to apparent dryness on the steam bath. Afterwards the containers were placed in an air oven at 102 deg. cent. (216 deg. fahr.) until the weights remained constant.

The data obtained are shown in Table 5. Values by the air-jet method are also given for comparison. It is seen that results obtained by evaporation in atmospheres of carbon dioxide or nitrogen are, in general, higher than those by the air-jet method. It was found that the method described was cumbersome and did not give reproducible results in addition to requiring an excessive amount of time. It was considered that evaporation under a nitrogen jet in a nitrogen oven at 100 deg. cent. (212 deg. fahr.) would be more convenient and might improve the reproducibility and reduce the time required. An apparatus for this purpose is now in the process of construction. It is planned to provide the oven with six jets which may be removed and permit its use as a steam oven. In either case, heating will be by electricity and it will be possible to study the effect of temperature as well as the effect of atmosphere.

TABLE 4—GUM CONTENTS OF BLENDED GASOLINES

First Gasoline		Second Gasoline		50/50 Blend Observed		50/50 Blend Calculated
138	141	10	8	63	64	74
37	36	18	19	25	23	27
16	13	20	20	17	17	17
97	92	18	17	58	57	56
125	123	2	2	55	57	63
103	99	10	11	61		56

Analysis of the Problem of Gum-Content Determination

If it is accepted that the criterion for a satisfactory method for gum-content determination is that it shall give the lowest value, it is to be concluded from the present work that the air-jet method is the most satisfactory of those investigated. However, this method does not entirely satisfy the 50-per cent relation, nor is there any good evidence that it obviates the formation of additional gum during evaporation. A logical method of ensuring freedom from transformation of potential gum into gum would be to use a solvent for gum which is immiscible with gasoline. *A priori*, the two conditions appear to be incompatible. In practice, however, it was found that an aqueous solution containing 90 per cent of ethyl alcohol had moderate extracting ability as regards gum and was reasonably insoluble in gasoline. Accordingly, some experiments were made with the intention of removing the gum by exhaustive

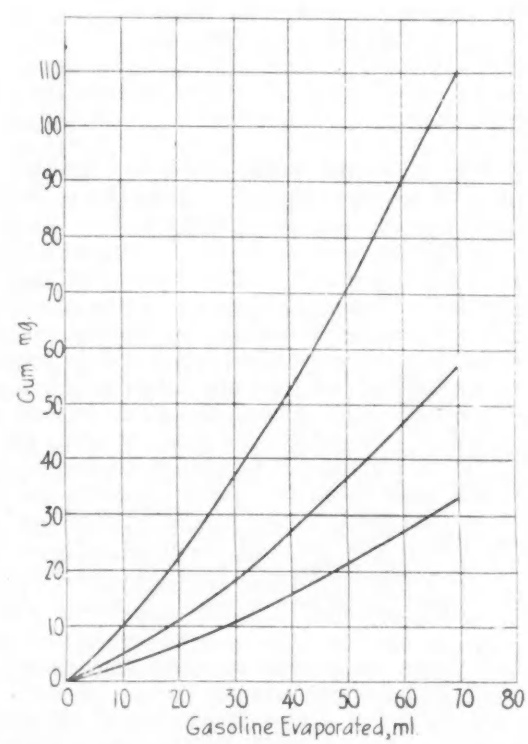

FIG. 5—EFFECT OF DIFFERENCE IN VOLUME OF SAMPLE EVAPORATED

Weight of Residue in the Dish Is Plotted against the Volume of Gasoline Evaporated by the Air-Jet Method

extraction and evaporating the extract liquid to dryness on a steam bath.

In doing this, 100 ml. of gasoline was shaken for 15-min. periods with successive 50-ml. portions of alcohol solution and each portion of extract liquid was evaporated to dryness separately. It was found that the distribution law held reasonably well and that prac-

tically all of the gum was removed in six extractions. This made possible an extrapolation to obtain the gum content of the gasoline. The results secured by this method are shown in Table 6. While the values are in fair agreement with those obtained by the air-jet method, it was found that in some cases the alcohol solution became completely miscible with the gasoline

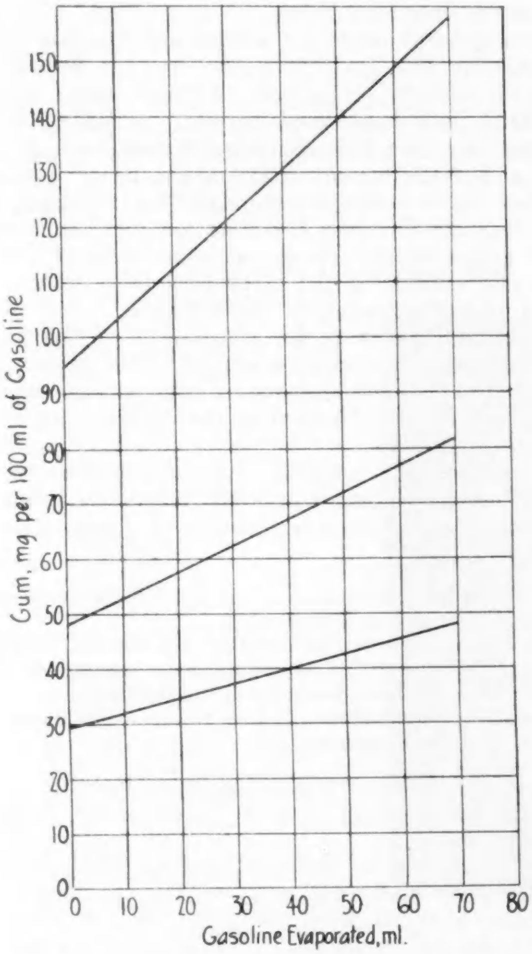

FIG. 6—CHANGE IN APPARENT GUM-CONTENT OF THREE GASOLINES WITH VOLUME EVAPORATED

The Intercepts Indicate the Gum Content Corresponding to Instantaneous Evaporation

after four to six extractions. Accordingly, the method was not investigated further.

Since none of the methods studied have shown capability of giving true gum-contents, it seems worth while to analyze the problem from the standpoint of the variables involved in the hope that the analysis may indicate a more promising mode of attack on the problem. Aside from the idiosyncrasies of gasoline composition, it appears that there are three variables involved; namely, (*a*) time of evaporation, (*b*) temperature and (*c*) atmosphere surrounding the gasoline during evaporation. All three of these variables have entered into each of the methods studied and in order to arrive at an entirely satisfactory answer to the problem, it seems necessary, therefore, to investigate the effect of each of these variables separately.

The independent study of the effect of time of evaporation on the results is particularly difficult and, in fact, it is hard to conceive of any method whereby this can be studied independently of temperature and atmosphere. Under these conditions, a logical method of procedure, if feasible, would be to make the determinations under conditions of instantaneous evaporation. The realization of this seems possible only by making determinations with various times of evaporation and extrapolating the results to zero time. One method of accomplishing this would be to evaporate a given volume of gasoline at the same bath temperature and in the same atmosphere in different lengths of time by varying the rate of air-flow.

Another method which could be used is the evaporation of different volumes of gasoline with consequent variation in the time required and the extrapolation to zero volume which coincides with zero time. Of course, the variables of temperature and atmosphere enter into all of these determinations at finite time of evaporation, but if their effects are sufficiently convergent their influence would be eliminated by extrapolation, and hence the intercept would represent the true gum-content of the gasoline. If the effects are not sufficiently convergent, which can be determined by experiments at various temperatures and with various atmospheres, it would be necessary to make an extensive series of tests of the effect of temperature and atmosphere on the values for instantaneous evaporation. The complexity of the problem of studying these variables cannot be determined until considerable experimental information has been obtained. This work is now in progress.

As an indication of one method of attack, some experiments have been made in which various volumes of gasoline have been evaporated by the air-jet method. The type of results obtained is shown graphically in Fig. 5, where the weight of residue in the dish is plotted against the volume of gasoline evaporated. The

TABLE 5—COMPARISON OF DATA OBTAINED BY EVAPORATION IN ATMOSPHERES OF CARBON DIOXIDE AND NITROGEN BY ONE METHOD WITH RESULTS BY THE AIR-JET METHOD

Sample	Evaporation from Flasks at Reduced Pressure: Carbon Dioxide		Nitrogen		Air-Jet Method	
	Milligrams of Gum per 100 Ml. of Gasoline					
A	9		..		13	
B	5		..		7	
F	26	26	..		12	12
Blend	13	17	..		8	7
G	36	26	..		15	11
Blend	25	19	..		8	8
H	136	131	..		70	87
Blend	86		..		25	30
I	57		..		25	28
Blend	38	37	..		13	15
J	132	152	..		46	51
Blend	60	63	..		24	21
T	..		35	33	24	24
Blend	..		18	17	18	15
U	..		27	18	24	21
Blend	..		15		10	11
V	..		154	159	109	
Blend	..		109	62	50	48

TABLE 6—COMPARISON OF DATA OBTAINED BY THE ALCOHOL-EXTRACTION METHOD WITH THE AIR-JET METHOD

Sample	Alcohol-Extraction	Air-Jet	
	Milligrams of Gum per 100 Ml. of Gasoline		
C	90	88	89
D	27	19	17
E	50	32	
E_1	25	16	

equations of the smooth curves through the plotted points are of the form $G = V\ (a + bV)$, where G is the actual weight of residue formed on evaporation of volume V of gasoline. This equation can be written in the form

$$100G/V = a_1 + b_1 V \quad (1)$$

where $100G/V$ is the gum content in each case calculated as milligrams per 100 ml. of gasoline, where a is the gum content corresponding to instantaneous evaporation and b_1 is indicative of the quantity of gum formed during evaporation. The curves for three gasolines are shown in Fig. 6, where the change in apparent gum-content with volume of gasoline evaporated can be noted. The intercepts represent values of a_1, or the gum content corresponding to instantaneous evaporation. While the work has not progressed sufficiently far to draw any conclusions, the method of attack appears promising.

A similar set of experiments has been made by Littlejohn, Thomas and Thompson[11], who found an analogous decrease in gum content with decrease in volume of gasoline evaporated. They presented their data both in tabular and graphical form and considered that the lines through the plotted gum-contents exhibited curvature. An analysis of their data, however, indicates that no justification exists for drawing other than straight lines through the points, which is in agreement with the preliminary information obtained in the present work.

The ultimate criterion of the satisfactory nature of a laboratory test for gum content is that it shall indicate the relative amounts of gum which gasolines will deposit in engines. The present investigation has shown that reproducible methods are available, but there is insufficient evidence to show that any of these is significant as regards gum deposition in the engine. Two general modes of attack might be employed. In the first place, accumulation of a large volume of engine-test data under a variety of operating conditions on a considerable number of gasolines, the gum contents of which were measured by the various available methods, might possibly indicate that one of these methods was satisfactory. However, there is almost complete lack of assurance that any of them would prove to be satisfactory and the acquisition of the test data is a very costly and time-consuming process. On the other hand, it is felt that a laboratory flow-method can be devised that will simulate engine-manifold conditions and which could be used as a preliminary criterion for the choice of method to be employed in the determination of gum content. Engine tests would then be necessary only as a check.

Two general modes of attack are likewise available in arriving at a suitable method for the determination of gum content. The first of these would consist in selecting, in a haphazard manner, various methods for comparison with the laboratory flow-method. The second and more logical mode would be to establish a method for the determination of the true gum-content and then use this as a basis for modification if data on true gum-contents cannot be successfully correlated with the results by the laboratory flow-method. This latter procedure appears more logical, since the true gum-content seems to be a property of the gasoline, independent of the method of test. The true-gum-content method therefore forms a very satisfactory foundation for the development of the desired routine gum-method.

In summing up, a logical mode of attack on the problem of the development of a significant method for the determination of the gum content of gasolines consists of three steps:

(1) The development of a method for the determination of true gum-content
(2) The correlation of data by this method, modified if necessary, with results by a laboratory flow-method simulating manifold conditions
(3) The verification of the above correlation by means of engine tests

It is planned to proceed along these lines in an effort to place the problem of gum in gasolines on a more rational basis.

The investigation reported herein was undertaken as part of an extensive program for the study of the gumming characteristics of gasolines and was made possible by the cooperation of the Army Air Corps.

[11] See *Journal of the Institute of Petroleum Technologists*, vol. 16, 1930, p. 684.

An Internally Cooled Exhaust Valve

Northern California Section Paper

By Manse M. Harris[1]

MATERIALS for exhaust valves, according to the author, should be able to resist corrosion and electrolytic action, should have high strength at operating temperatures, and should not air-harden. The metallurgist and steel manufacturer should be acquainted with the conditions under which the valve operates.

A new type of valve is described, through the hollow stem of which a stream of cooling-air is drawn by a Venturi exhaust stack which causes a vacuum in the exhaust port while the valve is closed. Heat is thus removed from the inside as well as the outside of the stem, and harmful temperatures are prevented. An incidental advantage is the elimination of the red exhaust flame without the use of an exhaust ring.

Successful tests of the Friedl valve were reported in the discussion by the inventor and the manager of a flying school under whose direction flight tests were conducted. These indicated that the temperature of the air-cooled valve during flight is several hundred degrees lower than of a conventional valve.

Test results and Indianapolis-Race observations were said to show that exhaust valves in engines having high compression are cooler than those in low-compression engines. Improvements in spark-plugs help to make higher compressions practicable.

MANSE M. HARRIS

HIGH SPEED, high temperature and the presence of sulphuric acid in the exhaust combine to fix the requirements for valve material upon a metal that will resist corrosion and have high tensile strength at temperatures often as high as 1700 deg. fahr. In addition, material must be able to withstand abrasion on the stem and seat and have sufficient hardness on the stem end to prevent mushrooming or upsetting from its operating contact with the valve push-rod.

In selecting a material it is further necessary that we consider the design of the valve itself. This will largely depend on the engine that is being considered, for many differeent valve designs have been successfully used. The tulip head, with many variations in depth, and the mushroom head, with flat or oval top, are used most commonly. The tulip head has met with considerable success in certain engines. Its streamline surface tends to permit the gases to flow more freely than do other forms, and its resistance to warping allows a valve to be made lighter by the removal of a considerable amount of material from the valve-head. However, we believe that many engine problems have been aggravated by not using sufficient material in the valve head; in other words, the cross-section was so thin that not even the best materials could hold their shape under the terrific strains caused by alternate heating and cooling.

My experience leads to the conclusion that a reasonably wide seat should be used, to aid in cooling through the seat. The high velocity of gases in the present high-speed engines has eliminated objections to wide seats which, in low-speed engines, caught particles of carbon on the valve seat and held the valve open.

Valve design is also influenced to a great extent by the design of the combustion-chamber, which is a big problem into which we cannot go here. Poorly designed combustion-chambers have been and are the cause of much valve trouble. Length of valve-stem guides, spring tension, lifting mechanisms and many other problems present themselves. Valve-springs that are too heavy invariably cause the valve to imbed itself in the port seat. If the material in the valve has insufficient strength at high temperatures, the stem will be stretched and the power of the engine will be most seriously impaired. It is almost amazing how many engines having very poor port seats are fitted with good valves. This is poor practice.

Corrosion Must Be Guarded Against

Corrosion is the most serious result of sulphuric-acid fumes or other gases in most internal-combustion engines. Corrosion usually is most active when the engine is not in operation and at varying, although low, temperatures. In some engines, particularly in radial aircraft engines, we encounter a further problem of electrolytic action, perhaps in instances where bronze, aluminum and steel are in certain relations.

It is difficult to determine definitely in some cases

[1] A.S.A.E.—President, Aerochrome Engine Valve Co., Ltd., Oakland, Calif.

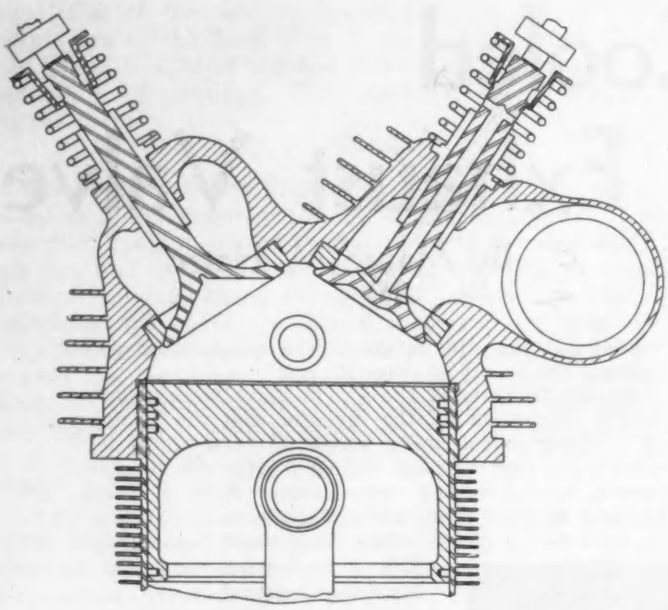

FIG. 1—FRIEDL AIR-COOLED EXHAUST VALVE APPLIED TO AERONAUTIC ENGINE

whether corrosion or electrolytic action has started the trouble. Our opinion is that much of the valve trouble starts from corrosion, although no evidence of corrosion exists after the flame has been in contact with the surface. At any rate, we should if possible provide materials that will eliminate both electrolytic and corrosive problems.

High tensile-strength or yield-point at high temperatures is a vitally important consideration in the selection of valve materials. We have examined hundreds of valves from the present high-speed high-compression engines that must have exceeded temperatures of 1650 to 1750 deg. fahr. Such valve temperatures result from abusive conditions, but nevertheless they are conditions that are brought into existence by Tom, Dick, and Harry who are operating the engines.

Since changes in engines and fuels are continuous, it is hardly likely that we can make a selection that will answer every problem. In the selection of steel, the chemist, metallurgist and steel manufacturer need to know the practical problems and experiences that arise from the varying conditions of engine operation.

Most of us believed for years that the steel should be hard, to assure long wearing life, but all steels that can be hardened at tempereatures lower than 1700 to 1800 deg. fahr. will have their hardness removed by heat in actual operation in many engines. Various manufacturers have used high-chromium, high-silicon-chromium and low-tungsten steels and other alloys that had promise of giving more desirable qualities. Tungsten steels have been eliminated because of scaling at low temperatures. Steels having a chromium content of 12 per cent or more are subject to grain growth under continuous heating and cooling, thus being weakened.

Air-Hardening Steels Are Objectionable

In addition, high-chromium steels, as well as many other alloys, have a tendency to air hardening, in fact do air harden; and air hardening is a property that we believe should be eliminated entirely if we are to expect long service from valves. It is not uncommon to find a Shore hardness of 75 or 80 in valves after use in an engine, even though they have had the benefit of salt filling or other methods of heat conduction. Such extreme hardness is, in our opinion, damaging to valve-port seats; and it is no assurance that the material is strong at high temperatures, because many of these same valves are found to be elongated so much as virtually to destroy the efficiency of the engine. Valve materials that are hardened or that have any air-hardening qualities should be eliminated, particularly from engines used in aircraft and heavy-duty motorcoach or motor-truck service in hilly or mountainous country.

Such valves may be annealed and hardened a dozen times a day, thus aggravating the growth in grain structure. So long as the material is subject to elongation at engine temperatures, we will encounter lame engines and burned valves and valve seats. Therefore, our conclusion is that we should use a material that is not susceptible to heat-treatment, in other words, that cannot be hardened by any method except perhaps work-hardening.

Cooling of Valves

Salt filling has perhaps been used more than any other method for cooling valves, but it has not solved all valve problems. It has to some extent been successful; but it is expensive, and it is impossible to use in many engines. Aircraft engines have been the most successful with this type of valve. Salt, copper, aluminum and other mediums have been used with varying degrees of success, although not nearly to the point

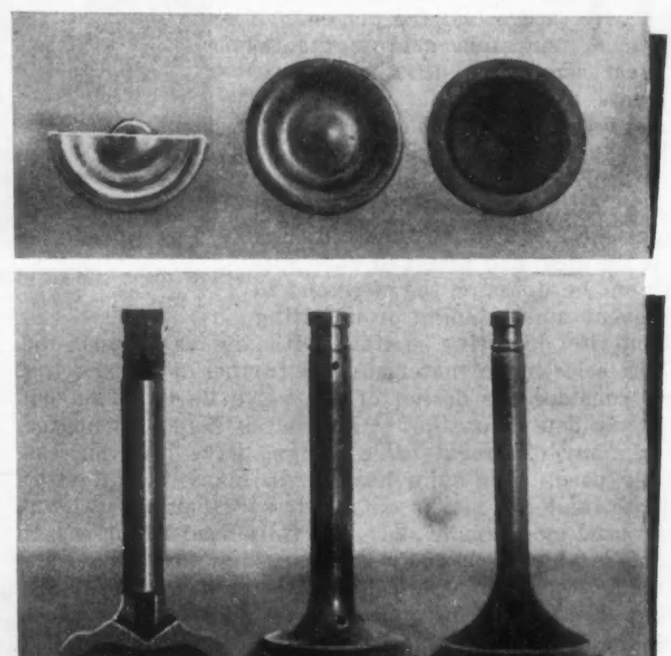

FIG. 2—VALVES FROM TEST ENGINE

The Two Valves at the Left Are Exhaust Valves of the Friedl Design. The Two Valves at the Right Are an Exhaust and an Inlet Valve as Taken from an Axelson Engine after 45 Hr. Service in an Instruction Airplane. The Color and Freedom from Carbon of the Exhaust Valve Are Said To Indicate That It Has Not Run Hotter than 900 Deg. Fahr. or as Hot as the Inlet Valve from the Same Engine

at which we can conclude that they have satisfactorily solved the problem. Another method, the Friedl, that involves air-cooling, we will refer to later. Rapid heating of the engines has caused many salt-filled valves to swell and crack, thus losing all of the effectiveness of the salt as a heat conductor and leaving the valve more helpless that one which never had it, so it seems that we are being led farther and farther away from the use of steels that can be heat-treated.

In those engines wherein it is not practicable to use the Friedl cooling system it seems that a material is needed which is resistant to the destructive agencies encountered in the engine, and with this system it is desirable to use such material; therefore we should demand that a material for exhaust valves must have the following properties, all of which are available:

(1) High strength at high temperatures, enough so that the stem will not stretch at maximum engine temperature
(2) No scaling at maximum operating temperature
(3) Resistance to the acidic or gaseous corrosive condition in the engine
(4) Freedom from air-hardening

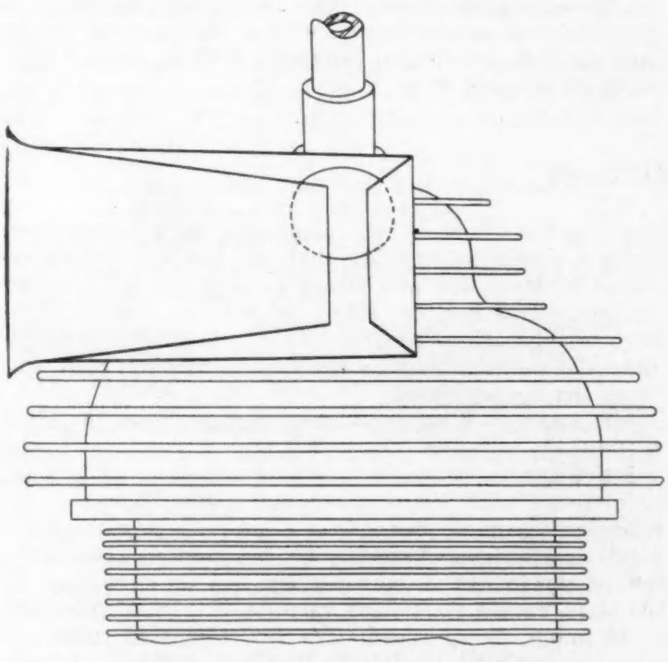

FIG. 3—VENTURI EXHAUST STACK

The Vacuum Caused by the Venturi Draws Air through the Hollow Valve-Stem

(5) Resistance to abrasion
(6) Ability to withstand mushrooming at the tappet end
(7) Shore hardness number not greater than 50 nor less than 35 at the valve seat
(8) Grain structure that will not change at engine temperature.

That these qualities are attainable is proved by the fact that hundreds of thousands of valves are in use that have operated over distances of 200,000 to 400,000 miles in heavy-duty engines used on motor-trucks and motorcoaches, in many instances covering from 40,000 to 80,000 miles per regrind.

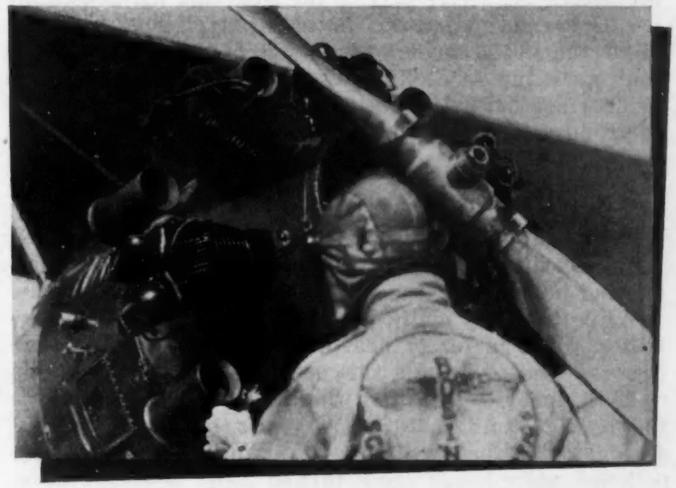

FIG. 4—SEVEN-CYLINDER AERONAUTIC ENGINE WITH VENTURI EXHAUST STACKS

Cool Air Passes through Friedl Valve

I have had experience during the last year with a valve invented by Ralph Friedl, a refrigeration engineer who has had aviation experience. I have helped Mr. Friedl in his experiments and have had an opportunity to observe the experiments with this valve which have been conducted under the direction of T. Lee, Jr., during the same period at the Oakland airport, where this valve and method of cooling have been in use for several months applied to one or two radial engines on airplanes belonging to the Boeing School of Aeronautics.

A section of the valve as applied to a Wright Whirlwind J-6 engine is seen in Fig. 1, which also shows the exhaust port at the right, with the central section of the Venturi tube. A photograph of three valves is reproduced in Fig. 2. The valve at the left is a Friedl exhaust valve sawed open at each end. In the center is a similar valve, showing the holes at both ends of the air-passage. At the right an inlet valve taken from the same engine is shown. As will be seen from these illustrations, a large air-passage is provided from near the end of the stem to a point close under the head of the valve, with a small number of radial holes at the stem end and a larger number at the head end.

Used in combination with this valve is an exhaust port in the form of a Venturi tube as indicated in Fig. 3. The dimensions of this Venturi are such that the air-blast from the propeller in an airplane traveling at 100 m.p.h. will produce a vacuum of approximately 5 in. of mercury in the exhaust port, thus drawing a stream of air through the valve-stem and out of the port with the exhaust valves closed. An Axelson engine to which the Venturi stacks were fitted is shown in Fig. 4.

The air-inlet orifices in the valve-stem are smaller in combined area than the passage through the stem, which is called the expansion chamber. The number and size of the outlet orifices, close to the head, are such that their combined area is greater than that of the expansion chamber. Since the expansion chamber is in communication with the Venturi, the air therein is below atmospheric pressure. This causes an air draft through the stem and somewhat of a refrigerating effect from the expansion of the air, which assists the cooling by radiation. It is to be noted that the cool

air enters the cooler part of the stem and the heated air is discharged from the hottest part. The air-draft from the outlet orifices is directed against the valve seat, assisting in cooling it. The angle at which these orifices are drilled is such that the escaping gas tends to produce suction rather than increased pressure in the expansion chamber while the exhaust valve is open.

Inside of Valve-Stem Is Cooled

This cooling system is permanent, as it does not depend on maintaining tightness in any piping or containers and plugging of the passages is improbable.

While previous methods of assisting valve cooling by aiding the transfer of heat depend finally upon removing the heat through the outside of the stem, this method removes heat from the inside surface as well as the outside surface. Several tests have conclusively demonstrated the effectiveness of the system. Brightly polished valve-heads have turned only to straw color during 180 hr. service, indicating that the maximum temperature was less than 1000 deg. fahr.

Night flying is helped by the Friedl system, since the Venturi exhaust stacks emit only a faint blue flame, instead of the ring of red flame ordinarily issuing from the exhaust stacks of an aviation engine. Therefore, the exhaust manifold can well be dispensed with, eliminating its weight and the back pressure and parasitic resistance which it causes and allowing the pilot better vision both by day and by night.

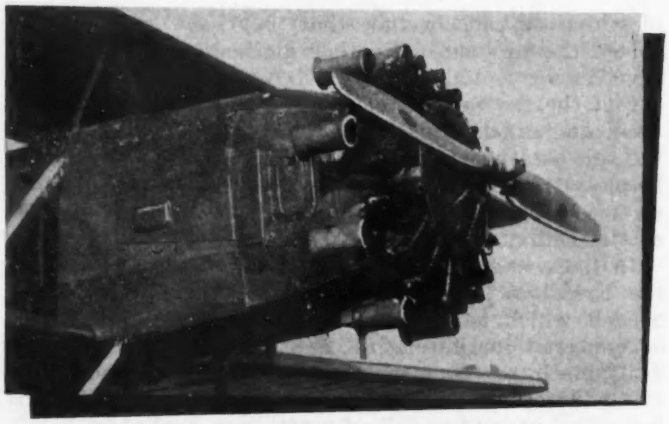

FIG. 5—FRONT OF WASP-POWERED BOEING AIRPLANE HAVING FRIEDL AIR-COOLED VALVES AND VENTURI EXHAUST STACKS

The system has been found to prevent burning, sticking and warping of the exhaust valve, to make daily greasing and servicing unnecessary and to obviate frequent regrinding, and it makes possible unlimited wide-open operation of the engine without danger of damaging the valves. This is accomplished with no power-driven accessory and with a reduction in weight and air resistance when compared with an engine fitted with an exhaust ring.

THE DISCUSSION

SIDNEY B. SHAW[2]:—Have you made comparative measurements of the temperatures of Friedl and other valves operating under the same conditions?

MANSE M. HARRIS:—I shall ask Mr. Friedl to answer that question.

RALPH FRIEDL[3]:—The only way we had of measuring the temperature of valves in the early days of aviation and during the War was by drilling a hole in the manifold through which we could see the hottest point of the valve-stem. More recently, use has been made of the visual pyrometer, which consists of an electric light bulb heated by a measured current. The temperature can be computed from the voltage of current that is required to make the filament match the color of the metal. This method is used by Harry Miller in developing his racing engines. The valves of these engines open 4000 times per min., and no other method could be employed to measure the heat.

RALPH FRIEDL

We cannot measure the temperature of an airplane-engine valve during flight, and the Venturi operates only while the airplane is flying, but the colors of the valves and the freedom from carbon adhesions indicate that the temperature is reduced between 400 and 600 deg. fahr. by the Venturi cooling. The cooling effect is greater during full-throttle operation, because the air is drawn through the valve more rapidly by the greater vacuum resulting from the higher speed.

MR. SHAW:—What vacuum is available from the Venturi tube?

MR. FRIEDL:—We have produced a vacuum up to 5 in. of mercury with Venturi exhaust stacks; however, no more vacuum is needed, and a Venturi to produce more would cause excessive parasitic resistance. The Venturi shown in Fig. 3, which is the one we have used in the tests, causes a constant vacuum of 2 in. of mercury at 85 m.p.h. flying speed. The little Venturi tubes on the turn and bank indicators that are used on the mail planes will produce a vacuum up to 20 in. of mercury.

Flying Tests of Friedl Valve

T. LEE, JR.[4]:—The Boeing School of Aeronautics is ready to aid in developing any promising new idea in the aeronautic industry. When I saw the drawings of Mr. Friedl's valve I recognized a possible solution for the greatest weakness of the present radial engine, and we offered to assist Mr. Friedl in its development. We equipped a 150-hp. seven-cylinder Axelson engine with his Venturi air-cooled valves, as shown in Fig. 4.

No serious difficulty was encountered with the valves, but it was necessary to take down the engine because of connecting-rod trouble at the end of 45 hr. The straw color of the exhaust valves indicated that they had never reached a temperature of 900 deg. fahr., and two of them retained their original polish to such a

[2] M.S.A.E.—Automotive engineer, Pacific Gas & Electric Co., San Francisco.

[3] Refrigeration engineer, Oakland, Calif.

[4] General manager, Boeing School of Aeronautics, Oakland, Calif.

degree that a reflection of the face could be seen in the valve-head.

After overhauling, the engine was run for 130 hr. longer, the whole 175 hr. being in the course of our regular dual and solo instruction work. No test of an engine is harder than this, because of the inexperience of the pilots. This was one of our nine instruction planes and was flown by as many as 40 different students. We do not ask the students to treat this engine differently from others in any way. The students liked the engine so much that they asked for the plane in which it was mounted in preference to other similar planes. It was used in the instruction work from the beginning of the dual instruction and including all maneuvers and stunts and transport license tests such as are given after 200 hr. of instruction.

T. LEE, JR.

A comparison of the performance of the same engine and plane before and after the Venturi air-cooled valves were installed, with no other change, established the following points:

(1) The speed of the engine at full throttle was increased from 1775 to 1900 r.p.m.
(2) The weight was reduced 34 lb.
(3) The visible blaze was eliminated from four of the seven exhaust ports.
(4) The exhaust noise was reduced about 15 per cent.
(5) The speed of the airplane was increased 5 m.p.h.
(6) The engine had better acceleration.

Further experimenting might reduce the noise still more. Mr. Friedl has developed a Venturi tube which eliminated all blaze from the 425-hp. Pratt & Whitney Wasp engine on the test stand.

The only disadvantage is a peculiar whistle produced by the Venturi tubes while the plane is in a dive. This is similar to the screaming of the wires during a very steep dive.

Tests Continued on Other Engines

This test of the valves ended when the airplane having them landed in the bay. A careful check of the valves after this accident showed that the sudden bath of the hot valves in salt water had warped several of the inlet valves but none of the exhaust valves.

We are now equipping a Wright J6-5 165-hp. engine and a Pratt & Whitney 425-hp. Wasp engine with Venturi air-cooled valves for further tests.

Mr. Friedl made one test in which an engine was operated without benefit of the Venturi exhaust until the valve was heated to cherry red. Then he put the Venturi into operation and the valve was cooled so that it became black in 42 sec., although the head was exposed to a constant temperature of 1300 deg. fahr. This test indicated that the Venturi effect reduced the temperature by 500 deg.

HOWARD A. REINHART[5]:—I have learned a great lesson this evening about what can be accomplished by cooperative effort, because the Boeing Company has cooperated with a man who had an idea. Lack of cooperation, particularly in regard to the patent situation, is hindering the development of carburetion more than anything else.

Does anything in the development which Mr. Harris has reported offer any solution to difficulties with valves of automobile engines?

Improvements in Automobile-Engine Valves

MR. HARRIS:—The best solution we can now see is through the use of austenitic steels, which are not magnetic, or in producing a higher grade of steel to which the manganese, chromium, nickel and other alloys are added.

MR. REINHART:—Operators who are here will agree that we are far from having satisfactory valves in motorcoaches and motor-trucks.

MR. HARRIS:—Austenitic-steel valves in good seats will help greatly, but there is little use in putting good valves in poor seats.

CHAIRMAN MILTON DAVIES[6]:—I must agree with Mr. Harris. The design of the cylinder-head is one of the most difficult problems in connection with a high-duty engine. If the head cannot be kept in shape no one can make valves that will stand up in it.

MR. HARRIS:—My experience has shown that it is very difficult to produce satisfactory valves for some Diesel engines. I have in mind several different engines in which the valves did not warp, burn or corrode in the usual way, but the seats of the valves looked as if they had been pounded with a ball-peen hammer—the material was highly resistant to heat, but not hard. We have failed so far to find the cause.

HOWARD A. REINHART

A VISITOR:—I have had some experience with Diesel engines but have never seen the effect that Mr. Harris mentioned. Perhaps it may be due to the high sulphur content to which Diesel fuels are more subject than is gasoline.

CHAIRMAN DAVIES:—I should like to ask Mr. Reinhart to tell what is the relation between compression ratio and valve temperature.

High Compression Favors Valve Cooling

MR. REINHART:—Contrary to what might be expected. the exhaust temperature drops as the compression rises. I know of one six-cylinder engine that was used for experimental work here on the Pacific Coast. When equipped with a cylinder-head giving 5:1 compression-ratio, the pyrometer reading showed the exhaust temperature to be about 2100 deg. fahr. Substituting a 6:1 head reduced it to 1800.

Very little valve trouble was experienced at the Indianapolis Race last Memorial Day. Only two cars

(*Concluded on p. 239*)

[5] A.S.A.E.—Sales engineer, Ethyl Gasoline Corp., San Francisco

[6] M.S.A.E.—Chief experimental engineer, Caterpillar Tractor Co., San Leandro, Calif.

Stainless Steels for Automotive Parts

Cleveland Section Paper

By M. J. R. Morris[1]

PREVENTION of economic loss from the rusting of ferrous products has been sought by engineers in various ways. Stainless steels are offered as one remedy. The author shows that these steel should be divided into three classes, according to whether they are to resist corrosion under atmospheric, wet or heat conditions.

Every trace of scale, iron oxide and contact with iron that might oxidize must be eliminated from the surface to prevent staining, which will extend far beyond the contamination. All carbon in the steel should be in solution, and rouge containing iron oxide should be avoided in polishing.

Extensive polishing equipment has been installed by manufacturers of sheet-metal for the fabrication of parts that require a high degree of polish. Steel for structural or decorative uses has its resistance to corrosion increased by a nitric-acid treatment known as passivating.

Basic compositions of steels in the three classes are tabulated, and the physical properties of a few of them are given. A bibliography of articles and books on stainless steels is appended.

Forging experience was reported in the discussion by men representing one organization that has done extensive testing and another that has forged from 25 to 40 tons of the material per month. The impact test of a sample that was not heat-treated was found to be exceptionally high. The material is considerably more difficult to forge than carbon steels but easier than high-speed steel or Monel metal. Close temperature control and skillful handling are required. The procedure for successful welding was described, and the prospect for less expensive stainless steel was discussed.

One important point brought out was that an imperfection which allows corrosion of stainless steel does not lead to rapid deterioration, like rust under the coating of plated steel.

FIG. 1—GENERAL VIEW OF REPUBLIC STAINLESS STEEL POLISHING DEPARTMENT
The Machines Shown Have Moving Tables and Endless Polishing Belts

AS engineering developed from an art into a science, the engineer's responsibilities increased. Bridges changed from wrought iron to steel structures which, to the minds of many, looked like tissue paper; but they have stood. Nevertheless, a question has been in the background as to whether or not any unseen or insufficiently protected part is rotting, rusting or corroding away. Several major accidents due to the localized deterioration of ferrous products have been recorded, among them the collapse of the great span of the Charing Cross station in London.

This worry as to the ravages of the elements came only to the group which bears the first responsibility. Coatings of various kinds were evolved as mitigants, but the question still remains as to whether this rusting is entirely prevented.

That the loss by rusting each year is very great has now begun to dawn upon the world; it has even been stated to be equaled to the yearly output of ferrous products. While this cannot be true, the losses are enormous.

[1] Chief metallurgist, Central Alloy division, Republic Steel Corp., Massillon, Ohio.

Investigations were begun, the real object of which was to secure improvement in the stability of the surface of ferrous products. The solution that came, as in many other cases, was due to the demands of an armed conflict. It was based upon the parent alloy of chromium and iron, resulting from the monumental work of Brearly and Haynes, which is the foundation of a much broader structure that is being built rapidly.

The alloy was used first to resist deterioration in a gun barrel. Its next application was in cutlery, from which came its unfortunate designation as "stainless steel," which has retarded the recognition of its broader aspects. Materials of this class are used to resist the ravages of the elements, of acids and of gases at high temperatures.

From the original stainless steel, which could be hardened, several chromium alloys have been produced—chromium steels, chromium irons, chromium-silicon steels, chromium-nickel steels, chromium-nickel-silicon steels and chromium-nickel-molybdenum steels—each contributing definite qualities and suitable to meet certain demands.

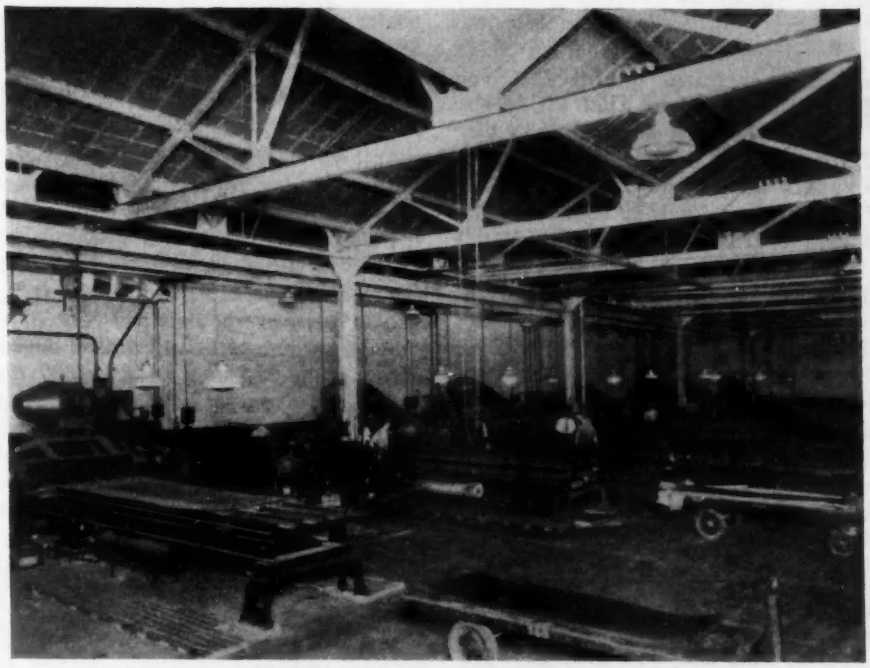

Fig. 2—The Final Buffing of Stainless-Steel Sheets
The Polishing Rolls Oscillates as the Tables Move, Thus Preventing Lines on the Sheets.

A major development such as this, as can readily be seen, involves complicated legal questions. Fortunately, the legal aspects of the development are being simplified.

Our analysis of the field will be simplified, if, instead of using the word "stainless" we speak in terms of the stability of the surface in resisting: (*a*) the atmosphere, or atmospheric corrosion; (*b*) liquids, or wet corrosion; and (*c*) scaling, or dry corrosion. Each of these conditions demands specific qualities and its own chemistry. Out of the chaos is emerging the fact that, as in the other lines of metallurgy, no one steel is suitable for all applications.

Steels Resistant to Atmospheric Corrosion

Resistance to atmospheric corrosion imposes the greatest difficulties. Defects that develop are entirely out of proportion to the initial defects, and brown rust or stain is so apparent upon a highly lustrous white ground. Early in this development it was found that obvious chemistry would not assure a stainless product; that tarnish would appear if the base was not properly prepared. Much patient observation disclosed that a surface which seemed perfect to the eye would sometimes tarnish if it was not entirely free from scale. Any scale left imbedded in the surface because of insufficient pickling or grinding and buffing will eventually break down or weather, and the products of this action will cause a stain that may become a pit extending over an area many times the size of its cause.

Too much emphasis cannot be placed on the fact that scale must be completely removed. To make sure of this, it is necessary either to over-pickle, making a surface that is unsuitable for many fields of application, such as automobile, or else to grind the surface after pickling, so that it can take a high polish. Any scale or iron oxide remaining in contact with the product will cause the surface to break down. Such a result is sometimes caused by grinding grit which is contaminated with iron or from the use of unsuitable polishing powder. The use of jewelers' rouge, which contains iron oxide, instead of green rouge, which is composed of chromium oxide, is liable to cause stain, as is also contact with a die or shear having a surface with which proper precautions have not been taken.

The foregoing may make it seem that the product is finicky and troublesome. Such is not the case, it is only necessary to remember that a stable surface is required and that nothing must be permitted to contaminate it which is or can become unstable. Polishing powders, grits and automatic machines for grinding and buffing have been improved enormously during the last year, so that parts now are polished in a fraction of the time that was formerly required. Some of the equipment for this purpose that is in use in the Central Alloy plant of the Republic Steel Corp. in Massillon, Ohio, is shown in Figs. 1 and 2.

Two classes of finish are recognized, one for automotive parts and the other for structural work, which does not require such a high finish. Typical sequences for finishing are to polish with No. 150 Lionite, No. 180 Lionite and No. 200 Turkish emery and buff or to polish with No. 180 Lionite and No. 200 emery and buff. The Lionite is a synthetic abrasive which is sharper than the Turkish emery. Buffing compounds consist chiefly of aluminum compounds or chromium oxide, and are furnished by several well-established firms. Structural material for buildings should always be immersed in 30-per-cent (by volume) nitric acid for 30 min. at 130 deg. fahr. This treatment, which is known to the trade as passivating, increases the stability of the surface. No other acid has the same result.

Chemical specifications for chromium and chromium-nickel steels that are characteristic of those used to

resist atmospheric corrosion will be found respectively in lines 1 and 2 of Table 1. These are basic types which are modified slightly by different manufacturers. Other formulas are being tried, but consideration of them would unduly complicate this paper.

TABLE 2—PHYSICAL PROPERTIES OF SOME TYPICAL STAINLESS STEELS

Alloy, Per Cent					Coefficient of Expansion, 0–100 Deg. Cent., In.	
Chromium	Nickel	Yield Point, Lb. Per Sq. In.	Ultimate Tensile-Strength Lb. Per Sq. In.	Elongation, in 8 In., Per Cent	Per Deg. Cent.	Per Deg. Fahr.
16–18	..	45,000– 55,000	70,000– 80,000	18–22	0.0000096	0.0000053
18	8	40,000– 50,000	85,000– 95,000	45–55	0.000016	0.0000088
12–14	..	45,000– 55,000[b]	80,000–100,000[b]	18.0[b]	....	....
		55,000–180,000[c]	100,000–200,000[c]	10–20.0[d]	0.0000102	0.0000056

[b] Annealed.
[c] Heat-treated.
[d] Heat-treated, elongation in 2 in.

Steels Resistant to Wet Corrosion

Resistance to wet corrosion demands totally different qualities from the foregoing. High finish is not required, and the suitability of steels depends entirely upon their physical, metallurgical and chemical qualities. Even with correct chemistry, it is important that all of the carbon in the alloy shall be held in solution. If any of it is precipitated, pronounced localized wet corrosion may occur. For this service we are concerned with the stability of the surface against solution. To be successful in resisting corrosion, the surface must contain a protective film. This can be helped by eliminating all scale, so that local corrosion is removed and galvanic action is prevented.

No alloy is suitable to resist all acids. The simple chromium alloys resist nitric acid in all concentrations almost perfectly, but results are entirely different with sulphuric and hydrochloric acids. Hadfield used sulphuric acid in his experiments, so failed to observe the valuable properties of the chromium alloys.

Fundamental types of steel representing the special alloys to resist wet corrosion are as follows:

12-14 *Per Cent Chromium.*—This alloy has good physical qualities and good resistance to corrosion from sea water and many other liquids.

16-18 *Per Cent Chromium.*—This alloy is highly resistive to nitric acid.

16.5-20 *Per Cent Chromium,* 7-10 *Per Cent Nickel.*—Resists nitric acid well and sulphuric acid fairly well but is poor in hydrochloric acid.

2-2.5 *Per Cent Silicon* added to the foregoing gives an alloy that withstands nitric acid and is better in sulphuric acid than the alloy without silicon, but it also is poor in hydrochloric acid.

Modifications of these types include the addition of molybdenum and tungsten.

One difficulty that has been observed with stainless steel and chromium plating in the automobile industry can be easily explained. When these materials are placed within 18 in. of the ground, early deterioration always results. This is due to the practice of spraying roads with calcium chloride, hydrolysis of which produces hydrochloric acid that attacks the chromium.

Steels Resistant to Dry Corrosion or Oxidation

Chromium is the fundamental alloying element also in alloys of the third group, which must resist the scaling or dry corrosion from gases under the influence of heat. The 18-per-cent alloy is decidedly superior to the 14-per-cent, and the 25-per-cent is still better. Additions of silicon are important in this group, reducing the percentage of chromium that is required. Silcrome valves contain about 9 per cent of chromium and 3 per cent of silicon and can be used successfully up to a temperature of 925 deg. cent. (1697 deg. fahr.). Because of the requirements as to physical strength, the parent alloy has been modified to include nickel, silicon and tungsten. Lines 3 to 8 of Table 1 set forth the chemical composition of several valve steels, as reported by Dr. J. A. Mathews. The steels shown in lines 3 and 4 have been superseded. That specified in line 6 is very popular, line 7 is a specification used for airplane-engine valves and line 8 represents a formula that is received favorably in Europe.

The exhaust valve is only one application requiring steels resistant to hot corrosion. Articles by Dr. J. A. Mathews, C. M. Johnson and W. H. Hadfield, listed in the appended biliography, present additional data on the subject.

Physical Properties of Stainless Steel

Physical properties of the chromium and chromium-nickel types of steel at atmospheric temperature are given in Table 2. The first two lines of this table refer to the same steels as are listed in lines 1 and 2 of Table 1. The 12 to 14-per-cent chromium alloy is a free-cutting steel quenched in oil at 1750 deg. fahr. and drawn at 1200 deg. The physical strength and forming qualities of the materials for resisting wet corrosion are not usually of great importance. In cases where strength is required, I believe that the strength obtained by cold-working should not be depended upon, except in special instances, as this causes a dangerous state of instability. If the strength is insufficient that is obtainable with a complete solution of the carbon, or in the softest state in the case of austenitic chromium-nickel and chromium-nickel-silicon steels, the sections should be redesigned. Experience has supported this stand in several cases. The 12-per-cent-chromium type, containing sufficient carbon, is being used in the heat-treated state for turbine

TABLE 1—CHEMICAL COMPOSITION OF REPRESENTATIVE STAINLESS STEELS, PERCENTAGES OF VARIOUS ELEMENTS

	Carbon	Manganese	Silicon	Chromium	Nickel	Tungsten	Molybdenum	Cobalt	Phosphorus	Sulphur
	Steels Resistant to Atmospheric Corrosion									
1	0.10	30–50	1.10[a]	15–18	...	...	...	...	0.03	0.03
2	0.16	50[a]	0.75[a]	16.5–20	7–10	...	...	...	0.03	0.03
	Specifications for Valve Steels Given by Dr. J. A. Mathews									
3	0.60	...	...	3.5	...	14	...	...	...	...
4	0.30	...	0.4	13	...	...	...	...	...	...
5	1.30	...	...	12.75	...	...	0.75	3	...	...
6	0.40	...	3	9	...	...	...	...	...	...
7	0.40	...	2.5	12	7.5	...	...	...	...	...
8	0.40	...	1.5	14	13	2.2	...	...	...	...
	Steels That Can Be Used at 2000 Deg. Fahr.									
9	0.18–0.30	0.60–0.80	1–1.5	20–30	10–12	...	...	...	...	...
10	0.18–0.30	0.60–0.80	1–1.5	25–27	15–17	...	...	...	...	...
11	0.18–0.30	0.60–0.80	2–2.5	22–24	20–22	...	...	...	...	...
12	0.18–0.30	0.60–0.80	1–1.5	28–30	0–2	...	...	...	...	...

[a] Maximum.

blades, quenched and drawn to meet Navy specifications of 60,000 lb. per sq. in. proof stress, 100,000 lb. tensile strength, 20 per cent elongation, 50 per cent reduction of area and a maximum Brinell reading of 241.

Physical qualities of the heat-resisting group are not evaluated, except as to the requirement that the products must be fairly hard, have stabilized surfaces that will not deteriorate and the strength must not be reduced by embrittling due to coarsening of the grain. The qualities are best measured by the loss due to scaling at increasing temperature. The steels listed in lines 9 to 12 in Table 1 were found by Dr. Mathews to be successful with temperatures as high as 2000 deg. fahr. Nickel in the alloy usually is reduced for conditions of sulphur exposure.

Stainless irons tend to work-harden very appreciably when drawn between dies, although they show high ductility when tested with the surface free, as in a tensile test. It is common for the hardness to rise from 85 to 100 on the Rockwell B scale during cold drawing. This at first was thought to be an insurmountable obstacle, until suitable lubricants were developed. Now austenitic chromium-nickel steels are being drawn successfully in large quantities with the use of drawing compounds which generally have a lithopone base with linseed oil. This general type of compound has several modifications, all of them good. Straight chromium steels have not the same ductility, but they can be used in many cases with some alteration in the design of the part and the method of fabrication.

One question that seems to be undecided is what grade of finish should be purchased by the fabricator. The first impression seems to be that the less polishing the fabricator has to do, the cheaper will be his cost. This is not always true, because the highly polished sheets require more careful handling in shipment and in the factory, and the steel-maker must polish scrap and all if he does the work, thus increasing the cost of the wasted portion. If parts are symmetrical or the design is such that polishing is easy and if the production is large, the product can be polished by special machinery and it is not necessary to purchase the sheets with very high finish.

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THE DISCUSSION

O. A. PARKER[2]:—One thing that I have learned about the fabrication of stainless steel is that stronger rolls are required to roll a bar or sheet of it than for carbon steel of the same dimensions. Apparently the dies for working it also must be somewhat different from dies for similar operations on deep-drawing carbon stock. I understand that this stainless steel costs about 12 times as much as ordinary steel, something like 37½ cents per lb.

PAUL GYGI[3]:—We have made some trials at forging K-A-2 steel, having less than 0.15 per cent of carbon and other elements as indicated in line 2 of Table 1. We found that it forged very well from bar stock and developed surprising physical properties without heat-treating. The elastic limit was 64,000 lb. per sq. in.; ultimate strength, 100,000 lb.; elongation in 2 in., 51 per cent; reduction of area, 73.3 per cent; Izod impact, 118 ft-lb.; and Brinell hardness, 187.

We have forged other types of steel having similar properties except the impact value, which shows higher than any we have ever seen produced in the un-heat-treated state.

[2] M.S.A.E.—President, Parker Wheel Co., Cleveland.
[3] Metallurgist, Champion Machine & Forging Co., Cleveland.

Another specimen of the same stainless steel was quenched in water from a temperature of 1200 deg. fahr. The impact value and elastic limit were approximately the same as in the foregoing, and the hardness and other physical properties were a little higher, as follows: tensile strength, 105,000 lb. per sq. in.; elongation in 2 in., 49.0 per cent; reduction of area, 62.3 per cent; Izod impact 118.5 ft.-lb.; and Brinell hardness, 196.

Another specimen of the same stainless steel was quenched in water from a temperature of 1200 deg. fahr. The impact value was approximately the same as in the foregoing, and the hardness and other physical properties were a little higher.


O. A. PARKER

Will the hardness and physical properties of this steel be improved by increasing the carbon above 0.16 per cent?

M. J. R. MORRIS:—The physical properties are substantially the same with higher carbon.

MR. GYGI:—At how high temperatures can stainless steels be used successfully?

MR. MORRIS:—Some of the them can probably be used at temperatures above 2000 deg. fahr., some up to 2200 deg. Successful use is reported in one case at these temperatures, but the amount of experience behind this report is not enough to make it dependable. Unquestionably alloys are being used at 1800 deg., and some are subjected to higher temperatures.

Observations from Experience in Forging

S. A. HARRIS[4]:—With this metal as applied to cutlery, there was difficulty in keeping a keen cutting edge on knives, but recent developments have overcome this difficulty. One type of stainless steel that will hold an edge contains 0.65 per cent or carbon, 16.5 per cent of chromium and no nickel. This metal requires extreme care in heating and soaking for forging and hardening.

Mr. Morris's paper treated almost entirely of sheet metal. The organization with which I am connected has been interested in research and development regarding stainless-steel forgings since 1925 and fabricates 25 to 40 tons of it per month in normal times. One of the problems in forging is to minimize the amount of flash, all of which is virtually a total loss. Following are observations from the experience we have gained:

(1) Stainless steel forges easier than high-speed steel or Monel metal, but with considerably more difficulty than carbon steels.
(2) The tendency of the metal to air-harden reduces die life.
(3) Close temperature control is essential; too high heat or excessive soaking causes the metal to become coarse and crystalline, and too low heat shortens the life of the dies.
(4) Great skill is required on the part of the hammer operators and heaters.
(5) Die designs must be modified to prevent excessive flash.
(6) Sudden changes are encountered in hardness with drawing temperatures between 1000 and 1200 deg. fahr.
(7) In selecting a type of stainless steel, careful consideration should be given for each application to the method of fabrication, the physical properties and degree of corrosion resistance required, and the nature of the corroding agent.

C. G. SHONTZ[5]:—Does Mr. Morris recommend the use of stainless steel in contact with ordinary steel or iron? Since such care is required to eliminate iron products from the surface, it seems possible that bolting or riveting ordinary steel to stainless steel might set up some sort of an undesirable action.

MR. MORRIS:—They are being used together, but precautions are taken to prevent any staining or bleeding from showing on the surface.

Controlling Thermal Expansion

MR. SHONTZ:—Stainless steel containing 18 per cent of chromium expands less than ordinary steel, while that containing 18 per cent of chromium and 8 per cent of nickel expands more. Is there a possibility of producing a stainless product of intermediate analysis having the same coefficient of thermal expansion as ordinary steel?

MR. MORRIS:—That question arises in the oil industry and is very pertinent. Mr. Harris is better able to answer it that I am.

MR. HARRIS:—We make steel forgings containing 20 per cent of nickel, 8 per cent of chromium, about 0.35 to 0.40 per cent of carbon and 1 per cent of silicon. This material is very difficult to forge, because of its great strength at high temperatures. Its coefficient of expansion between 20 and 600 deg. cent. is 0.0000168 per cent deg. (0.0000076 per deg. fahr. between 68 and 1112 deg. fahr.).

MR. SHONTZ:—Stainless steel is being used in automotive work chiefly for light parts in which the cost of the material is a relatively small part of the total cost. The cost is still prohibitive for many of the heavier parts. As Mr. Morris had said, great advances have been made in methods for polishing during the last year or even the last six months. However, if the material has deep scratches or pits, requiring the use of a coarse grinding-wheel, the cost of finishing rises rapidly because of the difficulty in removing the grinding scratches. Such difficulties have been largely overcome in sheet and strip products, but bar stock, heat-treated articles and forged parts still have uneven surfaces and cannot be finished as well as sheet products.


M. J. R. MORRIS

Stainless steel does not have the same luster and brilliance as a plated product. However, pits are not so objectionable in stainless steel as in plated metal; because any resulting stains can be removed, temporarily at least, by the ap-

[4] Chemist and metallurgist, Steel Improvement & Forge Co., Cleveland.

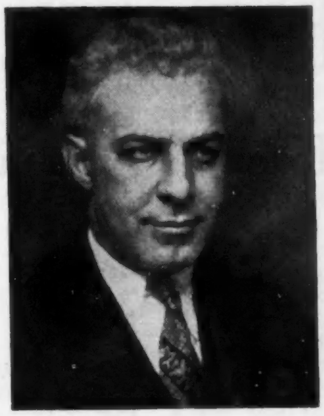
[5] Metallurgist, Eaton Axle & Spring Co., Cleveland.

plication of a little polish, and the material is not subject to rapid deterioration as is steel when rust gets a foothold underneath the plating.

R. R. ABBOTT[6]:—Some years ago there was a controversy regarding the effect of copper in steel in respect to corrosion. It was found that a copper content seemed to produce a better surface for painting.

Stainless Steels of Lower Cost

What developments are there in the way of stainless steel of much lower cost than those that are now in use, perhaps by the use of lower contents of nickel and chromium with the addition of copper or aluminum, which would resist corrosion fairly well when painted?



S. A. HARRIS

MR. MORRIS:—Steels of that sort are available now. Some of the first attempts at making stainless steel failed because they were made with too little regard to cost. It was expedient for success to make a product that was unnecessarily good in order to create the first impression. Undoubtedly there will be modifications in stainless steel, and no one knows how far the manufacturers will go in making products of lower cost. I understand that one steel company now makes about 80 varieties of stainless steel, but I believe that a little time will be required to develop the most successful steels of low cost.

Some of the most expensive cars develop blemishes in their plated finish before they are six months old. Owners of cars that are trimmed with stainless steel will appreciate their freedom from such defects and the ease with which they can be cared for.

J. S. ADELSON[7]:—Mr. Morris has greatly clarified the situation by classifying alloys for different purposes. What type of steel would he recommend for use in applications such as heating systems and evaporators at temperatures between 500 and 1000 deg. fahr., both wet and dry?

Low-carbon steel containing 18 per cent of chromium and 8 per cent of nickel now seems to cover the widest field so far as usefulness and workability is concerned. Mr. Morris called attention to the necessity for holding the carbon in solution in this alloy. The heat-treatment that is necessary to secure this condition is to heat the metal to 1850 deg. fahr. and cool it rather rapidly. Annealing is sometimes necessary because the metal work hardens so rapidly. Annealing at 1850 deg. makes the material more soft and ductile than any other treatment; it brings the hardness down to 80 on the Rockwell B scale and gives a higher ductility by the Olsen cupping test than for soft steel.

How Stainless Steel Is Welded

We have found that the same alloy is most readily welded. The flames for gas welding must be neutral or slightly reducing to prevent oxidation, but the molten metal will absorb carbon from the gas if the flame is too strongly reducing, and the weld will be brittle. There will also be a region near the weld in which carbon is precipitated, under these conditions, where corrosion will soon set in. The use of a flux that is made especially for welding stainless steels is advantageous.

This alloy is found to behave quite differently from ordinary steels in resistance-welding in that it does not have a range of temperatures within which it is plastic and weldable. Close control of the current is essential to keep the heat inside the narrow zone in which the metal is plastic. Too little heat fails to produce a weld, and a slight excess causes the material to melt way.

MR. MORRIS:—Any of the chromium stainless steels are suitable for temperatures from 500 to 1000 deg. fahr.; but care must be used under certain conditions if the steels are subject to prolonged duty within the range between 950 and 1000 deg. because they are liable to be as brittle as glass when they cool after such service. This condition can be avoided if the steel is occasionally heated to nearly but not over 1400 deg.

L. W. ADAMS, JR.[8]:—Mr. Morris has said that welds in straight chromium steels are brittle. Will any method of heat-treating make them soft?

MR. MORRIS:—Welding chromium steel causes pronounced crystallization, and the weld is liable to be brittle. If the steel has a great degree of toughness, as chromium-nickel steels have, protection is afforded. Chromium-nickel steel generally will stand a bend of 180 deg., which you would hardly expect from a straight chromium steel. Heat-treating will help the ductility of straight chromium steels to some extent, and much use of the material in welded form can be made if its limitation are respected.

[6] White Motor Co., Cleveland.
[7] Steel & Tubes, Inc., Cleveland.
[8] Steel & Tubes, Inc., Cleveland.

Wear Tolerances on Gages

Discussion of E. J. Bryant's Production Meeting Paper[1]

INCLUDED in the paper are recommendations for establishing wear tolerances as well as manufacturing tolerances for gages and definite periods for checking gages in service. Disposal of the manufacturing tolerance was discussed, and tables of tolerances recommended by the American Engineering Standards Committee were presented.

A study of the effect of gage wear and methods of inspecting gages, presented by a prominent gage engineer, leads the discussion which is presented herewith.

Sharp disagreement with the basis of the A. E. S. C. system of tolerances is expressed by representatives of leading automobile manufacturers, and a tabulation of tolerances is presented, based on standard reamer sizes, which have been adopted by both General Motors and Chrysler manufacturing units.

Warning is given by a gage manufacturer against the dangers that gage tolerances may either increase the cost of producing work, because of making the manufacturing tolerances smaller than intended, or allow work outside the specified tolerances. He said that methods of inspection should be selected that will produce results that can be accurately duplicated.

A parts manufacturer called attention to gaging problems arising from distortion of work after measuring, because of releasing casting, forging or chucking strains.

The author sees the need of two classes of limit, one based upon standard shafts and one upon standard holes. He emphasizes the fact that gages and tools are not an end but a means to an end.

A. W. SHOOF[2]:—Wear of gages is important from the aspect of its effect on the fit of mating parts and upon gage-upkeep expense. Which of these two is of the greater import may be decided by the assembly department or possibly by the customer for the product.

Gages naturally wear in service, and it is equally natural that maximum wear life be sought. Again, reducing gage manufacturing tolerance rapidly increases gage-manufacturing costs and reduce gage-wear life.

Before one can properly specify values for gage-wear tolerance and gage-manufacturing tolerance, it is essential that the system be definitely established by which product-manufacturing limits shall be controlled.

The simplest system is that which requires product limits to be absolute and in which gages as well as product are maintained within the limits, as recommended by the National Screw Thread Commission. The amount of tolerable wear on gages is indicated by the tolerances for the parts which are to be assembled; it is not proportional to their nominal size.

There are assemblies of three types: (*a*) those having some looseness, or positive allowance, under their tightest conditions of fit, as the N.S.T.C. Class 1; (*b*) probably most common, those in which the minimum-hole and maximum-stud dimensions are alike, as the N.S.T.C. Classes 2 and 3; and (*c*) interference fits, or negative allowances, in which at least some degree of tightness exists under the loosest possible conditions, as in the N.S.T.C. Class 5.

Wear of Go Gages for Various Classes of Fit

Type (*a*) is for assemblies which should be loose for purposes of economy or utility and is illustrated by Fig. 1. If the allowance has been proved to be critical as because of lubrication, temperature, or high-speed conditions, control of Go gage wear must be rigid to prevent reduction of the allowance.

Any wear of the Go gages in type (*b*) beyond their basic size will obviously permit parts to be accepted which will be unnecessarily and perhaps improperly tight in assembly, as indicated in Fig. 2. Therefore, the basic size for Go gages of this type should not be exceeded to a measurable degree, and we shall have to be satisfied with whatever wear we can get out of the manufacturing tolerance assigned to the gages. This type of fit requires recognition of the fundamental rule that the basic size forms the dividing line between mating part for interchangeability.

In interference fits, type (*c*), excessive wear of the Go gages will tend to increase the tightness with which the parts will assemble. If this is acceptable, as it may be under some conditions, it is a clear-cut indication that the Go limits have not been properly set. Fig. 3 shows this condition.

Manufacturing tolerance for Go gages should be as liberal a percentage of the product tolerance as can be spared.

Wear of Not Go Gages

Wear of Not Go gages, which control the loosest-fit condition, is generally of importance only because it reduces the working tolerance. Not Go gages usually outlast the Go gages, but they will wear also if users frequently attempt to see how tight a fit they can manage to make between work and gage.

Use of worn Not Go gages for types (*a*) and (*b*) assemblies works a hardship on the manufacturing department because of the reduced work tolerance and results in requiring the work to be better than the specified tolerances, because the mating parts are held closer to their nominal size by the amount of the gage wear.

Not Go gages for interference fits, type (*c*), when worn beyond their scheduled wear limit, tend to increase the normal tightness of assembly, besides giv-

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[1] This paper was published in the S.A.E. JOURNAL for November, 1930, beginning on p. 553. The author is manager of the gage and reamer department of the Greenfield Tap & Die Corp., Greenfield, Mass.

[2] Gage development and standards department, Western Electric Co., Chicago.

ing the machine operator more difficulty because of the reduced tolerance.

Both Go and Not Go gages, by their rapidity of wear, reflect machine or tool condition as well as careless use. Very small product tolerances are conducive to gage wear, because of the natural desire to prove, for instance, that a hole is large enough to receive the Go plug and also that the Not Go plug can be made to go. Much depends upon the user's judgment or instruction.

Extension of Gage Life

The practice of forcing gages during use is objectionable because of the resulting expense of frequent gage replacement and possible trouble from parts which will not assemble as intended. Machine operators and others who are working under pressure will take chances as to cleanliness of work and gage, and the temptation is ever present to prove that a Go gage will go, to pass the work. Theoretically, fixed or adjustable gages are best used by letting their own weight—or the weight of the work, if this is less—decide as to passability. Such use of gages will extend their life measurably as compared to forcing the gages. The matter simply is one of paying the user to take more time for gaging, or to pay for more gages. Usually the latter is the cheaper course, and it is safe enough if proper gage inspection is maintained. The advantage of gages made of wear-resistant material is obvious unless their cost, because of material, will not be offset by an equivalent increase of service.

Some of the harmful effects of gage wear are minimized by utilizing adjustable and indicating gages instead of solid gages whenever possible. Such gages permit frequent refinishing of worn contact surfaces without requiring more expensive replacement. Certain types of indicating gage should be watched for other forms of wear, as in their mechanism, to preserve their original accuracy of amplification and registration.

Wear of master gages, which are more properly termed check gages when they are used for checking the accuracy of working and inspection gages by direct contact, is also bound to occur. Fortunately, such wear is usually rather slow in becoming manifest, as check gages are ordinarily used by gage inspectors who know the value of cleanliness and care. It is difficult to establish a wear limit for these gages other than to rule that any measurable wear beyond their normal low limit will justify scrapping, unless the worn surface can be renewed by some method such as chromium plating and refinishing. The actual permissible extent of wear tolerance on these gages again depends upon the rigidity with which product limits are to be obeyed and can only be determined by a knowledge of the actual conditions.

Repairs of plain and thread plug and ring-gages for wear at the entering end or face may be made with unnecessary frequency. Slight wear is likely to be of little consequence unless close control of the size is required up to a shoulder or corner. When such a re-

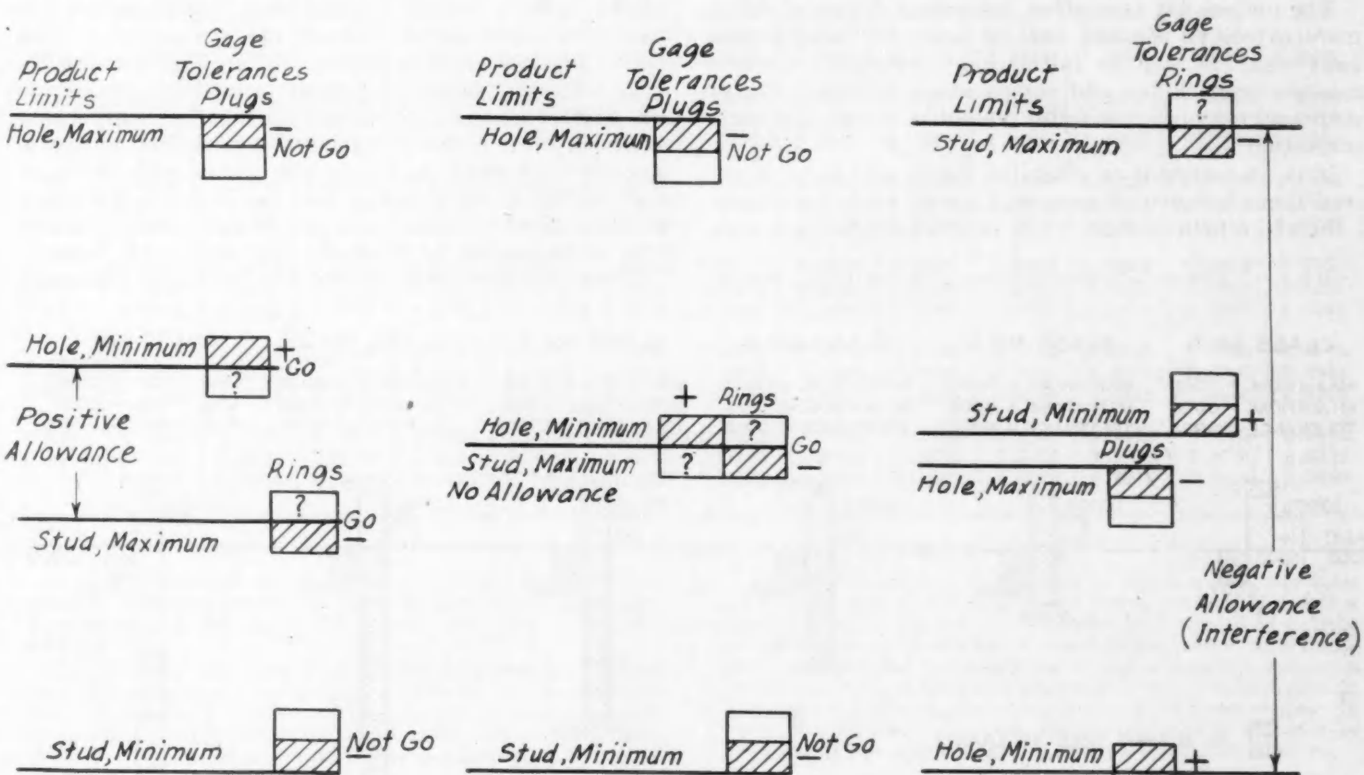


Fig. 1—Gages for Loose Fit
Wear of Go Gages May Be Permitted to a Percentage of the Allowance

Fig. 2—Gages for Ordinary Fits
Wear of Go Gages Makes Possible Undesired Tightness of Fit in Product

Fig. 3—Gages for Interference Fits
Wear of Go Gages Makes Possible an Increase in Interference

Diagrammatic Representations of the Effect of Wear of Gages

Product Limits Are Represented by Heavy Lines. Shaded Rectangles Represent the Manufacturing Tolerances on the Gages, Plus and Minus Signs Indicating the Direction, and Clear Rectangles Show the Direction of Wear on the Gages. Wear of Not Go Gages in Each Case Reduces the Manufacturing Tolerance on the Product

quirement does exist, it is sometimes permissible to grind away the worn portion if the gage cannot be relapped and readjusted. Such grinding should preferably not be across the entire face of the gage, as that might cause distortion of the gage by removal of the hard skin.

Determination of Gage Wear

Gages which perform their work with their external surfaces are best checked for wear by means of sensitive measuring equipment, such as a suitable measuring-machine or accurate micrometer.

The value of the optical projector for finding the effects of wear, especially on thread-gages, should not be overlooked.

Ring thread-gages are undesirable as checks for plug thread-gages, because their own accuracy is so difficult to determine.

Wear-limit checks, or plug gages made to the wear limit of the ring or snap gages to be checked, perhaps are not used as much as they might be. Their use will save much of the time that would be required for obtaining size values by other and perhaps less certain means.

Plain ring-gages and snap-gages are most conveniently checked by means of plugs, but some form of very sensitive and accurate measuring-machine will give better results if very small size deviations and out-of-rounders are being sought. This is particularly true in the larger rings in which differences of a few ten-thousandths are hard to feel with a plug.

The optical flat is another inspection device of which more extensive use can well be made for determining gage wear as well as initial gage accuracy. Certain measuring-machines and comparators utilizing one or more microscopes also offer valuable means for gage inspection.

It is inconsistent to establish limits and then to exceed them because of gage-making or wear tolerances. I therefore believe that, when product limits have once been definitely established, they should be adhered to as closely as possible with the available measuring equipment.

W. J. OUTCALT[3]:—At the request of David Ovaitt, I should like to register objection to the American Standard tolerances for cylindrical fits, as tabulated in Mr. Bryant's paper. The tool-standards subcommittee of the General Motors Corp. has spent considerable time in studying that, and has found it quite impracticable for our use. We have established a system of cylindrical-hole tolerances, which has been adopted also by Chrysler Motors, and are submitting it herewith as Table 1. The following is abstracted from the description accompanying the table.

Study of the committee made it apparent that the system of tolerances must permit the standardization of reamers, jig bushings and gages used in producing the holes. Neither the unilateral, bilateral or uni-bilateral system provides for the most economical method of producing the holes. A thorough study was made in the various plants of the Corporation, embracing 3500 holes up to 1½ in. in diameter, to determine how much over its own size a reamer will actually cut in various materials under different conditions.

It was found that, under normal conditions, a large majority of reamers produced holes less than 0.0007 in. larger than their own diameter, regardless of their size and the material being reamed. A system of six classes of tolerance was evolved, establishing the maximum hole at 0.0005 in. above each basic size in all classes. The minimum holes for the six classes are 0.0005, 0.0010, 0.0015, 0.0020, 0.0030 and 0.0040 below the maximum. The application of the system to a 1-in. hole is illustrated diagrammatically in Fig. 4 herewith.

No attempt has yet been made to establish standards for shaft diameter, which is left for the engineer to decide in each case. Frequently experiment is necessary for final decision, as the size varies with the kind of fit required, the material and the length. A change in shaft diameter after production has started causes little or no trouble, as it affects only adjustable tools.

A new reamer made within the tolerance indicated

[3] M.S.A.E.—Standards engineer, General Motors Corp., Detroit.

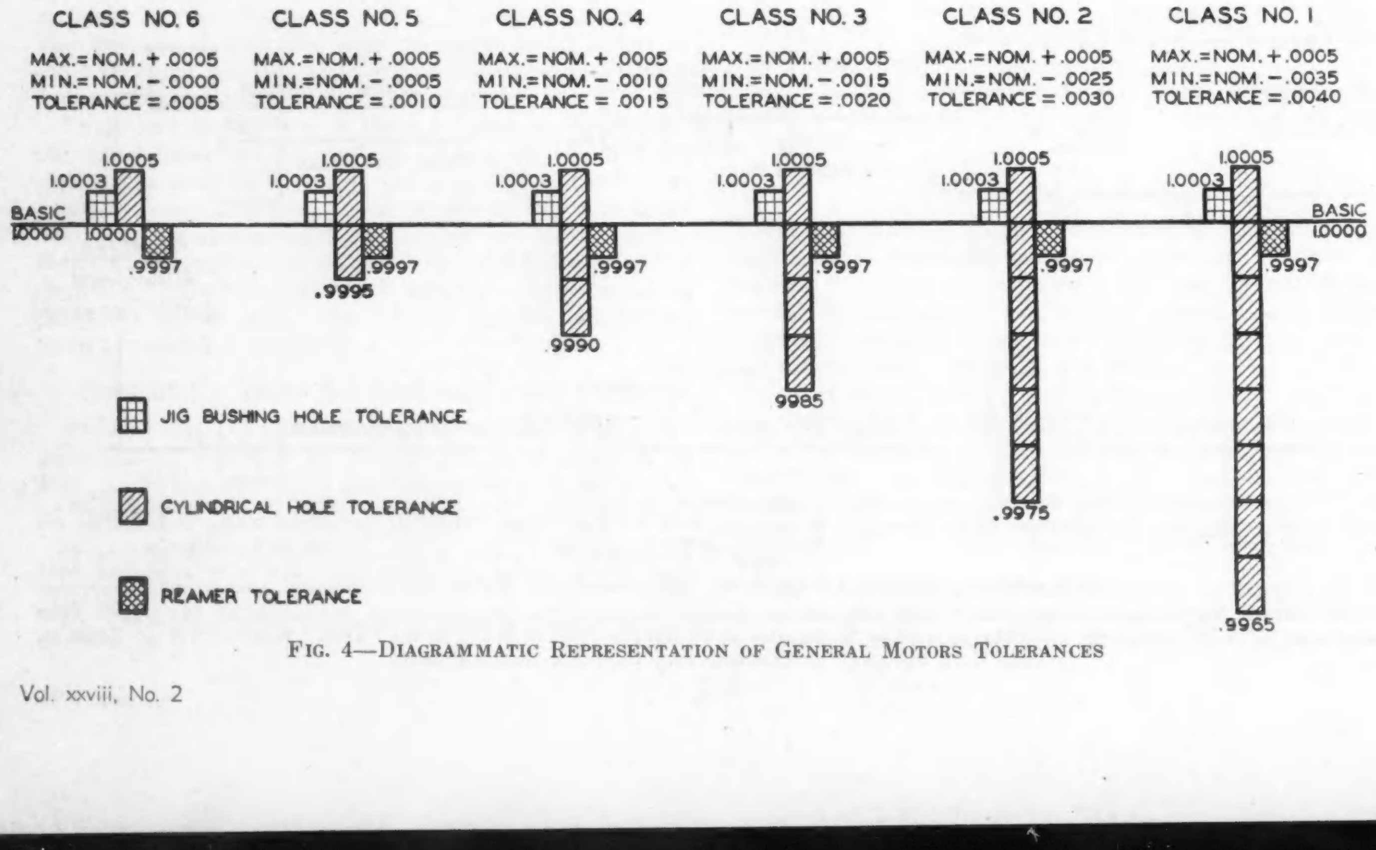


FIG. 4—DIAGRAMMATIC REPRESENTATION OF GENERAL MOTORS TOLERANCES

TABLE 1—GENERAL MOTORS CYLINDRICAL-HOLE TOLERANCES

Nominal Size		Class No. 6		Class No. 5		Class No. 4		Class No. 3		Class No. 2		Class No. 1	
		Max. = Nom. +.0005 Min. = Nom. −.0000 Tolerance = .0005		Max. = Nom. +.0005 Min. = Nom. −.0005 Tolerance = .001		Max. = Nom. +.0005 Min. = Nom. −.001 Tolerance = .0015		Max. = Nom. +.0005 Min. = Nom. −.0015 Tolerance = .002		Max. = Nom. +.0005 Min. = Nom. −.0025 Tolerance = .003		Max. = Nom. +.0005 Min. = Nom. −.0035 Tolerance = .004	
Fraction	Decimal	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/8	.1250	.1255	.1250	.1255	.1245	.1255	.1240	.1255	.1235	.1255	.1225	.1255	.1215
5/32	.1562	.1567	.1562	.1567	.1557	.1567	.1552	.1567	.1547	.1567	.1537	.1567	.1527
3/16	.1875	.1880	.1875	.1880	.1870	.1880	.1865	.1880	.1860	.1880	.1850	.1880	.1840
7/32	.2187	.2192	.2187	.2192	.2182	.2192	.2177	.2192	.2172	.2192	.2162	.2192	.2152
1/4	.2500	.2505	.2500	.2505	.2495	.2505	.2490	.2505	.2485	.2505	.2475	.2505	.2465
9/32	.2812	.2817	.2812	.2817	.2807	.2817	.2802	.2817	.2797	.2817	.2787	.2817	.2777
5/16	.3125	.3130	.3125	.3130	.3120	.3130	.3115	.3130	.3110	.3130	.3100	.3130	.3090
11/32	.3437	.3442	.3437	.3442	.3432	.3442	.3427	.3442	.3422	.3442	.3412	.3442	.3402
3/8	.3750	.3755	.3750	.3755	.3745	.3755	.3740	.3755	.3735	.3755	.3725	.3755	.3715
13/32	.4062	.4067	.4062	.4067	.4057	.4067	.4052	.4067	.4047	.4067	.4037	.4067	.4027
7/16	.4375	.4380	.4375	.4380	.4370	.4380	.4365	.4380	.4360	.4380	.4350	.4380	.4340
15/32	.4687	.4692	.4687	.4692	.4682	.4692	.4677	.4692	.4672	.4692	.4662	.4692	.4652
1/2	.5000	.5005	.5000	.5005	.4995	.5005	.4990	.5005	.4985	.5005	.4975	.5005	.4965
9/16	.5625	.5630	.5625	.5630	.5620	.5630	.5615	.5630	.5610	.5630	.5600	.5630	.5590
5/8	.6250	.6275	.6250	.6255	.6245	.6255	.6240	.6255	.6235	.6255	.6225	.6255	.6215
11/16	.6875	.6880	.6875	.6880	.6870	.6880	.6865	.6880	.6860	.6880	.6850	.6880	.6840
3/4	.7500	.7505	.7500	.7505	.7495	.7505	.7490	.7505	.7485	.7505	.7475	.7505	.7465
13/16	.8125	.8130	.8125	.8130	.8120	.8130	.8115	.8130	.8110	.8130	.8100	.8130	.8090
7/8	.8750	.8755	.8750	.8755	.8745	.8755	.8740	.8755	.8735	.8755	.8725	.8755	.8715
15/16	.9375	.9380	.9375	.9380	.9370	.9380	.9365	.9380	.9360	.9380	.9350	.9380	.9340
1	1.0000	1.0005	1.0000	1.0005	.9995	1.0005	.9990	1.0005	.9985	1.0005	.9975	1.0005	.9965
1 1/16	1.0625	1.0630	1.0625	1.0630	1.0620	1.0630	1.0615	1.0630	1.0610	1.0630	1.0600	1.0630	1.0590
1 1/8	1.1250	1.1255	1.1250	1.1255	1.1245	1.1255	1.1240	1.1255	1.1235	1.1255	1.1225	1.1255	1.1215
1 3/16	1.1875	1.1880	1.1875	1.1880	1.1870	1.1880	1.1865	1.1880	1.1860	1.1880	1.1850	1.1880	1.1840
1 1/4	1.2500	1.2505	1.2500	1.2505	1.2495	1.2505	1.2490	1.2505	1.2485	1.2505	1.2475	1.2505	1.2465
1 3/8	1.3750	1.3755	1.3750	1.3755	1.3745	1.3755	1.3740	1.3755	1.3735	1.3755	1.3725	1.3755	1.3715
1 1/2	1.5000	1.5005	1.5000	1.5005	1.4995	1.5005	1.4990	1.5005	1.4985	1.5005	1.4975	1.5005	1.4965
1 5/8	1.6250	1.6255	1.6250	1.6255	1.6245	1.6255	1.6240	1.6255	1.6235	1.6255	1.6225	1.6255	1.6215
1 3/4	1.7500	1.7505	1.7500	1.7505	1.7495	1.7505	1.7490	1.7505	1.7485	1.7505	1.7475	1.7505	1.7465
1 7/8	1.8750	1.8755	1.8750	1.8755	1.8745	1.8755	1.8740	1.8755	1.8735	1.8755	1.8725	1.8755	1.8715
2	2.0000	2.0005	2.0000	2.0005	1.9995	2.0005	1.9990	2.0005	1.9985	2.0005	1.9975	2.0005	1.9965
2 1/8	2.1250	2.1255	2.1250	2.1255	2.1245	2.1255	2.1240	2.1255	2.1235	2.1255	2.1225	2.1255	2.1215
2 1/4	2.2500	2.2505	2.2500	2.2505	2.2495	2.2505	2.2490	2.2505	2.2485	2.2505	2.2475	2.2505	2.2465
2 3/8	2.3750	2.3755	2.3750	2.3755	2.3745	2.3755	2.3740	2.3755	2.3735	2.3755	2.3725	2.3755	2.3715
2 1/2	2.5000	2.5005	2.5000	2.5005	2.4995	2.5005	2.4990	2.5005	2.4985	2.5005	2.4975	2.5005	2.4965
2 5/8	2.6250	2.6255	2.6250	2.6255	2.6245	2.6255	2.6240	2.6255	2.6235	2.6255	2.6225	2.6255	2.6215
2 3/4	2.7500	2.7505	2.7500	2.7505	2.7495	2.7505	2.7490	2.7505	2.7485	2.7505	2.7475	2.7505	2.7465
2 7/8	2.8750	2.8755	2.8750	2.8755	2.8745	2.8755	2.8740	2.8755	2.8735	2.8755	2.8725	2.8755	2.8715
3	3.0000	3.0005	3.0000	3.0005	2.9995	3.0005	2.9990	3.0005	2.9985	3.0005	2.9975	3.0005	2.9965

Notes

It is recommended that the above sizes be adhered to and specified wherever possible in designing production parts, jigs, fixtures or tools as these sizes permit the use of standard reamers.

If sizes other than those listed above are necessary, standard fractional sizes should be specified, using as the maximum dimension the nominal plus **.0005**. The minimum dimension should be specified as the maximum minus **.0005, .001, .0015, .002, .003,** or **.004** in accordance with the classes listed above, depending upon the requirements.

There are, of course, applications in which special size holes are required such as sliding and press fits on the same shaft. It is obvious that, for the press fit, a smaller hole is required and the full tolerance up to **.0005** inch above basic cannot be allowed. It is recommended in these cases to use a standard minimum dimension of one of the looser classes of fit and for the maximum dimension a minimum dimension of one of the closer classes. In doing this, standard gages can still be used and it will only be necessary to use reamers ground or worn to the size required.

in Fig. 4 may be expected to produce holes approximating the maximum limit for all classes. As they become worn down, they may be transferred from the finer to the coarser classes.

Experiments were made simultaneously with flute shape and degree of spiral. Considerable benefit was found in the majority of cases in the way of longer reamer-life by substituting for the conventional radial tooth a hook of 7 deg. on the face of the tooth and in the way of smoother holes in the majority of materials

by a right-hand spiral flute of 10 to 12 deg. For the softer materials a left-hand spiral of 8 to 10 deg. gives better results.

Jig bushings for both drills and reamers have been standardized on the basis of nominal size for the minimum hole, with a plus working tolerance. With these standards and a corresponding standard for drills, all drills, reamers and bushings can be drawn from stock and used without fitting or lapping.

Standard gages are necessary to complete the system. The gage blanks and handles are of the design worked up by the American Gage Design Committee. Seven gages are required for the six classes of tolerance of any one size; one Not Go gage for the maximum hole and one Go for the minimum of each class. That the shop may always work to the full limit, the original intention was to make a plus manufacturing tolerance only on the Not Go gage, but a split tolerance has been adopted pending a definite settlement of the question. The necessary allowance for wear on the Go gage automatically absorbs part of the working tolerance of the hole. If the Not Go gage is made smaller than the maximum limit of the hole, the working tolerance will be reduced still further. Therefore the minimum of the Not Go gage should be the same as the high limit of the hole.

Modern production-methods, as implied in high-production machine-shop practice, require that great economy be practised with perishable tools. The system here outlined standardizes the hole, the reamer, the jig bushing and the plug gages, making is possible to stock all the tools in quantities. Other systems invite the use of special reamers, bushings and jigs.

W. J. GOURLIE[4]:—The ability of the shop to produce work within closer tolerances than are required for satisfactory performance of the product is what permits allowance for wear on gages. Failure to heed this fact may result in either (*a*) increasing the cost of the product by an amount greater than that gained by lowering the cost of gages or (*b*) producing work that is outside the tolerances specified.

An example of (*a*) is the production of 25,000 parts at $1 each, using gages worth $50. It was found possible to cut the cost of gages to $20 by reducing the workmen's tolerance 25 per cent, to 0.0005 in. Because of the closer tolerance, the next lot of parts cost 1 per cent more, so that a net loss of $220 resulted instead of the anticipated saving of $30. Such a result may not always follow, but the example illustrates a point that is too often overlooked.

Exceeding the product limits (*b*) results from a plus tolerance of Not Go plug-gages. This practice may be acceptable under some conditions, but it is highly dangerous when the product is sold and is subject to reinspection by the customer. A single rejection might easily absorb the savings of several years in the cost of gages.

Mr. Bryant's point in regard to the finish of gaging surfaces cannot be stressed too strongly. A machine-lapped plug-gage will outlast a ground gage by an almost unbelievable amount. All high-production jobs should be checked with gages having the smooth finish that only lapping can produce.

Methods of inspection should be selected that will produce results that can be accurately duplicated. The measurement of the pitch diameter of thread plugs furnishes a good illustration of this. Many methods of varying degrees of accuracy were in use for this until the general adoption of the three-wire method. That method has recently been made more specific by requirements recommended by the Bureau of Standards and adopted by the National Screw Thread Commission[5].

Some of these newer requirements are:

(1) A measuring pressure of not more than 3 lb. for threads of 20 per in. and coarser and 8 oz. for finer threads

(2) All wires to be calibrated with exactly the same pressure as that at which the gage is to be measured

(3) All wires to be calibrated when crossed over an 0.750-in. roll.

ORREL A. PARKER[6]:—Mr. Bryant has made reference in his paper to the temperature of the work and the flexibility of the metal. Another difficulty is found in distortion of the metal in relieving strains. For instance, bearing seats may be machined within very close tolerances in the wheel hub, and be distorted within a few hours from this cause. This distortion is accentuated if the hub is machined both on the inside and outside. I have known of cases in which a bearing seat that is within close tolerances as to circumference is elliptical to such an extent that a Go gage will not enter across the short diameter and a Not Go gage will enter across the long diameter, yet the hub can be made round again by the application of a clamp having a screw with a 2-in. wing. Pressing the race of a ball or roller-bearing into place also will make the hub round.

Distortion of a part in the chuck has somewhat the same effect. Gages will pass the part while it is in the chuck, but will not pass it immediately after it is removed. Much difficulty from rejections may be solved by a thorough study of the distortion of a particular piece of work as a result of the relief of strains in machining.

E. J. BRYANT:—Ever since the subject of standardization of limits has been discussed, two schools have existed both in this Country and abroad. One of these prefers to base its system on the standard hole and the other on the standard shaft. Standard-shaft specifications are very desirable in some industries, particularly those using cold-rolled, cold-drawn or ground stock without machining. I believe that each practice has its field and doubt if one practice can become universal in industry. The practice established by the General Motors Corp. should be placed alongside that which is recommended by the American Standards Committee, as reported in my paper.

Turning out work to the required specifications is the main problem; gages and tools are means to this end, and we should guard against considering them the end.

Heat-treatment of gages has been mentioned. Much experimentation and great care has been expended to produce gages that are permanent. It cannot be said that anything that has yet been developed is definitely permanent, but gage manufacturers are now producing gages that are permanent within limits of a fraction of 0.0001 in. Most gages are worn out before they have much time to change.

(*Concluded on p.* 223)

[4] Gage division, Pratt & Whitney Co., Hartford, Conn.

[5] See report of the National Screw Thread Commission, 1928 revised edition; pp. 184 to 192.

[6] M.S.A.E.—President, Parker Wheel Co., Cleveland.

Aluminum Alloys

Used in Commercial Motor-Vehicles

Discussion of Frank D. Goll's Transportation Meeting Paper[1]

THE PAPER is confined to a discussion of aluminum for commercial motor-truck bodies and tanks. Following a statement that commercially pure aluminum is seldom used for structural parts except when alloyed with another element or elements such as copper, manganese, magnesium or silicon, and remarking upon new alloys available, the author considers the subjects of design, selection of a correct aluminum alloy for a particular purpose and like matters.

The advantages of aluminum bodies as to weight saving, low maintenance-cost, residual value and better appearance, are stated also, as well as the special advantages applicable to certain types of body now in operation. The paper also treats aluminum motor-truck tanks in some detail, and presents numerous statistical data in tabular form.

Comments on the methods of fabrication, shop practices and design values are made at the beginning of the discussion, and upon the relative cost of aluminum and of steel fabrication. Experience had with aluminum tanks is stated by two discussers, and some of the factors relating to fabrication costs are enumerated. Weight saving is brought out as a major factor that tire manufacturers are greatly dependent upon, and some further possibilities of saving weight are mentioned. In conclusion, some details of the experience of one manufacturer of aluminum bodies is stated.

A. E. GRESHAM[2]:—The methods of fabrication, shop practices, and design values set forth in Mr. Goll's paper have been strictly—and very successfully—adhered to in our plant for the last year in the fabrication of aluminum-alloy products. Any manufacturer following the methods outlined should have no trouble in fabricating.

I am very much in accord with Mr. Goll on the subject of corrosion. There has been so much said relative to surface and inter-crystalline corrosion of aluminum alloys that I find the average layman's conception of this material for structural work has been considerably distorted by only a superficial perusal of the subject. The laymen seem to think of aluminum-alloy structures as being unstable. Some even go so far as to believe that such structures, if exposed to atmospheric conditions, actually will melt and run down the sewer.

It is high time something was said relative to the inherent corrosion-resistance of aluminum alloy as compared with steel. In my opinion, if one-half the labor and material were spent upon aluminum-alloy structures that is spent on steel structures to protect them from atmospheric conditions, we should have practically no corrosion problems with aluminum.

I regret that I cannot agree with Mr. Goll's statement under the heading of "weight saving and its cost" that the fabrication cost of aluminum is the same or even less than that of steel. Later in the same paragraph he makes the statement that aluminum jobs, being of higher grade, rightfully received better workmanship and closer supervision. This is not logical. It is true that fabricated aluminum products receive better workmanship and closer supervision; consequently, the cost of fabricating is higher than if the product were fabricated from steel.

After one year of aluminum fabrication in our plant, we find that the relative cost of aluminum and steel fabrication, including the price of material, runs from one and one-half to three times the cost of steel. In welded products this is due to the fact that aluminum must be gas-welded, while steel is electric-arc welded; and gas-welding is a much slower process. In the higher-strength structures such as under-frame and mountings for tanks, where high-strength aluminum-alloys are used, it is impossible to weld these products. It therefore becomes necessary for us to rivet them to maintain the high-strength material. If these products were fabricated of steel, they would be electric-arc welded. Consequently, the relative cost between arc welding of steel and riveting on high-strength aluminum-alloy is much higher for the aluminum. However, in all cases, we find that the weight saved by the use of high-strength aluminum-alloy more than justifies this high cost of fabrication.

A. F. COLEMAN[3]:—We had four aluminum tanks fabricated at about the time the tanks referred to by Mr. Goll were put on the market. Two were of the separable-compartment type and two were made up exactly along the lines of the regular steel construction; that is, the wrapper sheet and the heads were welded together and there was a separate strap welded over the two compartments, which construction, in effect, makes a one-piece tank. We have been watching those tanks in service for the last year with great interest, and have had no trouble from leaks from either construction; nor have we had any structural failure in the tank itself.

We have found that the carrying capacity of the side

[1] The paper was published in the December, 1930, S.A.E. JOURNAL beginning on p. 637. Mr. Goll is a Member of the Society and engineer for the Aluminum Co. of America, New Kensington, Pa. The abstract that preceded the paper when it was published is reprinted for the convenience of the reader, and is supplemented by a brief summary of the discussion.

[2] M.S.A.E.—Engineer in charge of aluminum-tank equipment, Standard Steel Works, Kansas City, Mo.

[3] M.S.A.E.—Manager of the motor-vehicle department, Standard Oil Co. of New York, New York City.

racks is not sufficient to support the load. In other words, the bolsters were built along the same lines as the bolsters under the steel tanks, were constructed with the same factor of safety used in the balance of the tank, and apparently are not standing up under the load of the 5-gal. cans we carry in the side racks. We have had failures on the hold-down bands on three of the four tanks. We have not been able to determine whether these failures are caused by undue expansion in the tank, or whether it is just a structural failure. Another trouble we have encountered is a continual loosening of the bolts which hold the tank to the frame. Apparently, the nuts which hold down these U-bolts cut into the aluminum or wear the aluminum, allowing them to loosen. As yet, we have found no means of keeping these tight.

Bumper bars on the rear of the tank have failed, we think, much more easily than the ordinary bumper bars have. We have had a number of bent bars on the aluminum tanks. Also, we had one failure of piping under the tank due to backing a faucet into a platform. I believe that would not have occurred with steel piping. We are watching the aluminum tank with particular interest because it appeals to us as an economic means of transporting our products.

My only thought in making these constructive criticisms is because it may be necessary for us to adopt some different practice in the manufacture of aluminum tanks, other than that used for the steel tanks. Every other feature on an aluminum tank seems to perform just as satisfactorily as did the steel tanks. We have no trouble due to valve operation, manhole covers, or other features. One additional complaint was that the doors on the bucket box are perhaps not flanged as well as they should be, or perhaps the flange is not deep enough and there has been a tendency for the door to warp.

Fabrication Cost Considered

F. C. BUCHANAN[4]:—We have been very much interested in the development of the aluminum-tank body. I believe I can endorse most of what Mr. Goll stated in his paper; but I am inclined to agree with Mr. Gresham in the exception his company took regarding the cost of fabrication. It is true possibly that lack of experience in making tanks or other bodies of aluminum on the part of all, including Mr. Goll's company, will justify and explain the extra cost. Later, this probably will be reduced when arc welding is a little more perfected and other short-cuts to the same result are brought out.

Viewpoints on Weight Saving

A. M. WOLF[5]:—Regarding the saving of weight, in the case of the Auto Truck Equipment Co., Pittsburgh, in which a 5-cu. yd. steel-body was replaced with a 6½-cu. yd. aluminum-body, Mr. Goll showed the economics of carrying extra payload in view of that saving. In my paper on Practical Tractive-Ability Methods[6], I used some of his figures to show what the use of aluminum means in regard to giving better performance when keeping the total weight at the same figure. The truck with the steel body has a tractive factor of 0.048. However, a 5-cu. yd. aluminum-body will make a saving of 2000 lb. When the gross weight is reduced 2000 lb. we get a tractive factor of 0.053, or a gain of 10.4 per cent. In other words, if the payload is not increased, with an aluminum body, we get the equivalent of installing an engine having a 10.4 per cent greater ability in power output.

JAMES E. HALE[7]:—Probably, of all people connected with the automotive industry, the tire manufacturers have *weight* on their minds and have had it there ever since they have been operating. Fundamentally, our problems in rendering service are more wrapped up in weights, and in loads on the tires, than in any other characteristics of motor-vehicle operation. Our method of making showings are all based on trying to reduce the load on the tires. It seems as though we never finish the job. We are always facing the necessity for urging someone not to overload the tires. On the other hand, the operators are naturally interested in carrying as much payload as they can on any given vehicle; hence, from a rubber-manufacturer's viewpoint, this move to use material of lighter weight in any part of the vehicle intrigues the manufacturer to a very great extent.

As I see it, there is a great opportunity to present this weight saving of materials in many different forms. I think Mr. Goll is to be complimented on the method he used in applying the cost figures; but there are probably some other ways in which it could be presented that would strengthen his case still further.

Possibly there is some benefit in the fact that coal trucks, for instance, that are on return trips, are considerably lighter than they would be if they had the steel bodies. That must result in some saving. I know that it means some saving on tires, and it must mean some saving on gasoline and for the parts of the vehicle.

Why should this matter be confined to the bodies? I have had no occasion to check this; but what about the frames, fenders and axles, wheels and rims, and similar parts? I am particularly anxious about the weight savings possible in wheels and rims, in regard to favoring the tire equipment. Tires are expensive and anything that can be done to increase the life of tires by reducing the weight they carry is meritorious.

Concerning motorcoach-body construction, the attitude of the road and highway commissioners in Missouri is drastic. They wanted to rule some of the coaches off the highways because they exceeded the legal limits.

F. D. GOLL:—Aluminum frames, fenders, wheels and axles are being tried experimentally; it costs more to save weight here than on the body, and only in cases where the operator insists on the ultimate in reduced weight have the cost figures been really interesting to him. The rear wheels and the axles are more or less of an experiment, but they will come as soon as the truck operators insist upon having them.

E. A. CLARK[8]:—We have four aluminum bodies in the wholesale milk-service. and are now experimenting with aluminum bodies for the retail service. I calculated that a driver could haul about 84 qt. more milk because of the saving in weight, which would mean that we could serve 84 customers more each morning. That is about a 400-lb. saving, and this is in the retail service. We cannot save so much on the small bottles, but even that would be worthwhile. We have ordered

[4] A.S.A.E.—Sales Engineer, Columbian Steel Tank Co., Kansas City, Mo.

[5] M.S.A.E.—Consulting automotive engineer, New York City.

[6] See S.A.E. JOURNAL, December, 1930, p. 655.

[7] M.S.A.E.—Development department manager, Firestone Tire & Rubber Co., Akron, Ohio.

[8] Superintendent of automotive equipment, Rieck McJunkin Dairy Co., Pittsburgh, Pa.

four retail-trade aluminum-bodies; if they are successful, probably within the next 18 months we will have 60 of them on $1\frac{1}{2}$-ton chassis.

As to the tire proposition, we are successful with the standard-sized tires without using a tire that is really too big. In other words, we are using a 6.00-in. tire instead of the 34 x 7-in. size that we should have according to specification. With this aluminum body, we can get by with the smaller size of tire; it is a direct saving, and the saving we make on tire mileage is one of the considerations.

I have wondered why more effort is not made by the manufacturers of chassis to reduce the weight. Some years ago I drove a frame and a rear axle that were all aluminum. They weighed 2200 lb. as compared with 3100 lb. for steel, and the car was practically of the same size. The car mileage was much better on the old basis than on the new. But the manufacturers have abandoned that construction now. I think it is a matter of cost with them.

MR. GOLL:—Yes; principally.

Further Operating Experience

CHAIRMAN J. F. WINCHESTER[9]:—At about the same time that Mr. Coleman ordered aluminum tanks, our company ordered some. We have put about 30 into service since then, within the last year. In addition, we have built a large number of aluminum bodies.

The development of aluminum motor-vehicle-tank construction has perhaps been delayed because certain people felt that such vehicles were distinct hazards on the American highways; but a subsidiary company of our company that operates throughout Norway and Sweden has used aluminum tanks exclusively for the last 5 to 7 years. While talking with our foreign general manager, who was in this country recently, he stated that his equipment superintendent had brought to his attention no failures that he considered worth setting forth as being distinct hazards.

In our own operation, the saving in weight has been a very material one. To a certain degree, it depends on the type of body and on the type of tank truck that one uses. Engineers feel very much the same as they felt 10 years ago about substituting the welded steel-tank for the riveted steel-tank. They thought we were taking unnecessary chances. We began building welded tanks, and had some minor failures; but those who have observed tanks know that they are hauling gasoline very satisfactorily with all-welded tanks today, and but few would consider a return to the riveted type.

In connection with aluminum material, probably some failures will be encountered. I cannot say that the tanks that we have received have been altogether perfect. On the other hand, we must take into consideration the fact that we have increased the payload on some of these vehicles an average of between 16 and 20 per cent, and in some cases, the same payload is carried on a very much lighter chassis, thus making an original saving in chassis cost. As Mr. Hale stated, to a certain degree vehicles operate light approximately 50 per cent of the time; that is, they return to the station for another load. The result is favorable toward decreased tire and decreased chassis-upkeep. If the body is properly built no doubt exists in my mind that, over a period of time, the saving will be great.

Our experience with aluminum to date has been very satisfactory. With the careful study that is being given to the economical use of motor-vehicle equipment today, I am certain that the aluminum body has an outstanding place in the petroleum industry.

Manufacturer's Experience Stated

A. M. HAUBER[10]:—We realized several years ago that the reduced gross-weight of motor-trucks and bodies would become an important factor, as the real purpose of a motor-truck is to move payload; but nobody seemed to give this point much thought. Railroad engineers calculated on how to eliminate grades, straighten out curves and build locomotives large enough to haul 100 loaded freight-cars, never once giving a thought to reducing the weight of the railroad cars.

After having experimented with building aluminum into almost every kind of truck body that is used for hauling—excepting aluminum tanks and including a fleet of 18 dump-trucks for hauling coal as well as a fleet of 20 trucks equipped with insulated panel bodies for hauling milk in cans—we found aluminum to be a perfect substitute for steel in any type of body if constructed properly. The weight was reduced approximately one-third to one-half, depending on the amount of body hardware used, which would be the same in bodies built of any other material. There is a great saving in weight in aluminum dump-bodies. A dump body built of steel weights 2400 lb.; but if built of aluminum, using the same tailgate mechanism, it weighs only 950 lb.

We were unable to locate a fleet owner who had cost records which would enable us to determine just what a 100-lb. saving in weight meant in dollars and cents; but our investigation showed that, when times are normal, a price is added in proportion to the distance coal is hauled. A truck can make 8 trips per day traveling the distance for which a hauling charge of 75 cents per ton is made. Naturally, if a ton of steel body-weight is eliminated, and an extra ton of payload is carried, the company gets an additional 75 cents eight times per day, or \$6. A coal company no doubt makes a profit of 25 cents per ton on the additional 8 tons, or \$2. Charges are based on cost and where there is a charge of 75 cents per ton, haulage would no doubt cost 50 cents. But to be conservative, we will say that a truck on the return trip which is lighter by 1 ton makes a saving of 25 cents eight times per day, or \$2. Therefore, with no additional expense, the owner would increase his revenue \$8 and make a saving of \$2, or a total earned with the same investment of \$10 per day. On this basis, an aluminum body will pay for itself every six to nine months.

Thus far, we have had no failures. Aluminum bodies we have built have been in service longer than two years, doing every kind of work. They have proved to us that they more than justify the extra cost. We have had cases where slight repairs were necessary, just as we have had with wood and steel bodies. In every case the trouble could be traced to a mistake in estimating the necessary strength, to faulty workmanship, or to abuse.

One unique case of trouble occurred in which an owner used a certain kind of soap in washing an aluminum body daily; the soap in some way got between the

(Concluded on p. 233)

[9] M.S.A.E.—Superintendent of motor-vehicles, Standard Oil Co of New Jersey, Newark, N. J.

[10] President and general manager, Auto Truck Equipment Co., Pittsburgh, Pa.

Economic Motor-Transport Instruction

Discussion of Prof. James W. Trimmer's Transportation Meeting Paper[1]

SKETCHING motor-vehicle-transportation development, since the World War, inclusive of the large fleets of passenger and freight vehicles operating both locally and across country, the author says that we have seen automotive transportation grow from a local institution into a nation-wide one and automotive transport relieve the short-haul problem of the railroads, expanding into long-haul traffic for perishable goods and into motorcoach traffic for passengers.

The executive personnel with experience along transportation lines naturally was drawn from the steam and the electric railroads; but while it is true that its members had wonderful training in the handling of passengers and freight, and in meeting with officials of State and Federal regulatory bodies, they did not have the knowledge, training or experience for handling the independently operating self-contained motor-vehicle with its many and unique problems. The operating personnel had to be found and trained. How was it to be trained and along what lines was this necessary training to be given? The motorcoach operator had to have the qualifications of a salesman, conductor, driver and mechanic and, in addition, certain physical and mental qualities for the proper operation of the vehicle. The repair personnel had to be trained along new lines in the repair and upkeep of the vehicles if operation was to be economical and safe. The author then outlines and comments upon the valuable training course available at the Carnegie Institute of Technology.

Questions are raised in the discussion as to the desirability of including foreign languages in the courses of the Institute, and the difficulties of doing this are outlined. Professor Trimmer states that the courses are intended to cover transportation as a broad subject, without specializing in any one phase in particular.

Difficulties encountered in placing graduates in commercial positions are cited, and the attitude of graduates in general is criticized in that many do not wish to begin in subordinate or menial capacities. Various outlines of the schooling practices in vogue among large organizations in dealing with graduates from the various educational institutions are given.

S. M. UDALE[2]:—I note the absence of Spanish, Portuguese and French from the courses given. Since it is likely that there will be some foreign trade in South America, Spanish and Portuguese would be beneficial to men who become employed in it. A knowledge of French would enable men to understand the French trade-papers, which are well worthwhile from a trade viewpoint.

The general criticisms I offer of all similar courses in this Country is that they seem to be directed specifically toward caring for inadequately prepared high-school graduates. Far too many students are accepted. In the European university from which I graduated a three-year course was offered; but the entrance requirements were very severe. Provided that half of the present freshman classes were eliminated from most of the schools under discussion, I think that a three-year course would cover the needs of the situation.

If rural districts cannot maintain the high-school standards of the large city, then they must send their pupils to some large city to take the final year at a high-school there.

PROF. J. W. TRIMMER:—Mr. Udale's criticism is a good one. However, entrance requirements are supposed to cover the question of including foreign languages. We cannot specify that a student entering our school shall have a knowledge of French, German, Spanish and the like; but we accept a foreign language. For those who have no foreign language to offer as an entrance qualification, they must add that to their course so as to pass the entrance examination.

It is quite true that high-school graduates are, as a rule, less well prepared for college than they should be. For this reason it is difficult to spare the time needed to teach modern languages in college. Many factors interfere with the laying out of a curriculum such as I have outlined. The high-school graduates lack in subjects of the liberal arts and these subjects are taught in college to the exclusion of science subjects.

If allowed to do so I could easily tie in three or four more main subjects with my course. But I cannot do this because the authorities feel that more refinement must be given to this education in regard to sympathy for fine art, nature and so forth, so that, when it comes to having the boys get their hands soiled while taking the hard and practical courses, one course must be robbed to pay for the other.

PAUL P. PIERCE[3]:—Is a course in drawing included? Is the course in typewriting necessary?

PROFESSOR TRIMMER:—In the freshman year a course is given in descriptive geometry; in the junior year, under the head of mechanism, kinematic drawing is given; in the senior year, under the heading of machine design, the students are required to design a given machine and to turn out finished working-drawings of that machine. The engineering drawing and descriptive geometry given in the freshman year consist of a one-hour lecture and six hours in the laboratory. In none of my courses do I demand that the student turn in his reports typewritten, although many of our

[1] M.S.A.E.—Professor of automotive engineering, Carnegie Institute of Technology, Pittsburgh, Pa. The paper was published in the November, 1930, issue of the S.A.E. JOURNAL, gebinning on p. 541. For the convenience of readers, an absteract of the paper and the discussion is printed herewith.

[2] Holley Carburetor Co., Detroit.

[3] M.S.A.E.—Engineer, Vacuum Oil Co., New York City.

courses are given by lectures and the students must turn in their notes in typewritten form.

MR. PIERCE:—Does the course in electrical engineering in the senior year cover both alternating-current and direct-current practice?

PROFESSOR TRIMMER:—Yes, but it is not an electrical engineering course. It is a good sound grounding on alternating-current as well as on direct-current machinery.

Elective Course Advocated

A. H. GOSSARD[4]:—It seems that at some time during the senior year, or possibly in the junior year, a division point should be established so that the student can decide what field of automotive operation he would like to enter after graduation. In railway operation, the divisions are management, engineering, traffic, and operation. The commercial side of the automotive picture will, in time, I believe, require these same divisions. At present, very little stress is laid upon them.

I do not find any training regarding traffic control specified in Professor Trimmer's course, and I think such training is important because, from the commercial standpoint, rates, schedules, and the like become important factors.

PROFESSOR TRIMMER:—It would be very difficult to establish a division point where the student could take up some specific subject that would train him into a certain division of fleet operation. The college I attended had nine major options, I took eight of them because I had certain credits that permitted me to do so. When I left college and went to work, the work related to the one option which I did not take. The same is true of men who elect automotive-service management as a course. A peculiar fact is the reluctance on the part of the motor-transport operators to take a college-trained man into their business. There is that reluctance. I do not know why. The greater portion of the men who have taken our course and then gone into a job have connected themselves with accessory manufacturers and they are making good. But only one man has gone into motor-vehicle operation, after having been out of college for a year.

Although the paper does not specifically mention the establishment of rates and the like, under the auto-service-management course I lecture to the students in the second semester of the senior year on these subjects and other kindred ones. We cannot subdivide and mention all of the details of the major topic that is named. Under Auto-Service Management, which is a unit course, three hours each week are devoted to plant visits. In Pittsburgh, industry is very diversified and the students can be taken to visit various plants as seems most advisable. For example, we have the Pittsburgh Motor Coach Co., the Equitable Auto Co., service stations of the various companies, and the independent garages.

MR. GOSSARD:—As to the future, we will have to draw our automotive-transportation traffic-men from among those who have had railroad-training experience, or from some school that specializes in traffic management or traffic training.

PROFESSOR TRIMMER:—We try to cover transportation as a broad topic and not as a specific course in traffic training. We could not very well specialize in traffic conditions because it is likely that the operators of motor-vehicles would be reluctant to employ a graduate who they feel is just "a fresh college kid."

ADRIAN HUGHES, JR.[5]:—I feel that Mr. Gossard's suggestion is important. It should be recognized that all college courses do not turn out a finished product. They merely teach the young men how to use the tools at hand; then these men must get a job and learn what to do with the tools they have. If a man takes a course in engineering, he must enter a business so as to apply his knowledge. The course outlined does not seem to me to contain enough teaching that would train a man so that he would be eligible as an employe of a transportation operating-company.

The course seems to stress "service" particularly, or the maintenance of motor-vehicles; but the transportation field is becoming more and more complicated and I think it has room particularly for college-trained men. There may be a reluctance on the part of an operator to employ such a man at present, but in many instances this is caused by the applicant in that he virtually applies for an executive position and does not want to learn the business from the ground up as dispatcher, for example.

In the transportation field, the business depends upon laying out the service scheduling, getting business from the public, knowing how to sell the business to the public and how to get the revenue. Trained men are needed for this. Thus far, it has often been necessary to call on men who have had such experience in the electric and in the steam-railway field. These men, in such service, practically have had a course in economics. A very important part of economics is getting the revenue; I think this is a point that perhaps should be considered more seriously.

PROFESSOR TRIMMER:—We had a course up to and including 1929 called "fleet operation," but this is now combined with the auto-service-management course and the same instruction in fleet operation is still given in the course just mentioned. It is a lecture course of 2 hr. per week and is devoted in the senior year to all phases of fleet operation that can be covered in the time allotted to it.

MR. UDALE:—Possibly there is opportunity to help break down the resistance against graduates who try to sell their services to transportation companies in that the course might be sandwiched in over a six-year period. The transportation question is largely a matter of practical psychology which a man does not get in a college atmosphere. Nothing there would give him the knowledge that would bring revenue to transportation companies.

"Cadet" Training Outlined

H. B. HEWITT[6]:—We have an arrangement with one of the colleges so that its students work in our shops in teams of two men each for three months. At the expiration of three months the team-mate in the shop returns to college and the team-mate in the college goes to work in our shops. Some of these men are studying mechanical engineering and some electrical engineering. Their work is passed upon by a foreman and by the division manager. When these men complete their course in the college, a certain number are employed as cadets.

[4] M.S.A.E.—Manager of the automotive department, Middle West Utilities Co., Chicago.

[5] M.S.A.E.—Superintendent of bus transportation, United Railway & Electric Co. of Baltimore, Baltimore, Md.

[6] Engineering assistant to vice-president in charge of operation, Mitten Management Inc., Philadelphia.

A cadet goes through all the departments of the organization. After he has completed his cadet course, he is given certain responsibilities. If he fulfills them, he can work his way up through the organization. In Buffalo, some of these men have risen from the ranks and have become division managers.

The particular advantage of our plan is that the old-time employes are thus associated with younger men possessing technical knowledge which is of great value to the older employe. When an older employe wants to know, for instance, why certain parts must be held to certain tolerances, the student can answer intelligently.

MR. PIERCE:—When your students visit various plants are they required to make written reports which give some indication of what their conception of these plants is?

PROFESSOR TRIMMER:—Yes; and sometimes they are required to turn in a floor plan and also to give reasons why it is a good or a bad plan or to make recommendations for changes in that plan which will improve it. I criticize and grade these reports and, just previous to a plant visit, I talk to the students about the plant so that they will be alert in observing its special features.

Scientific Motor-Vehicle Application

F. C. HORNER[7]:—For several years I have had the privilege of lecturing to the classes of Professor Cunningham of Harvard; of Prof. James J. Hill of the Harvard Business School; and to those of Professor Wilson of the University of Pennsylvania, on this general subject of automotive education. As I come into contact with motor-transport operators and with the men who are looking for jobs in that field, the point that stands out in my mind is that there is a great dearth of men who understand the scientific application of motor transport, whether it be that of passenger or of freight transportation.

PROF. JAMES W. TRIMMER

The criticism that I would make of what the colleges are doing is that *they are not concentrating enough on the application phase* of the subject. Operating men know that they can get fairly good maintenance-men if they search for them and are willing to pay enough money for them. But men who really understand the science of applying motor transport to haulage requirements are very difficult to find, and this is the real problem with which we are faced. We must take a motor-truck, or a fleet of motor-trucks, or motorcoaches, and apply them scientifically so that they can transport either passengers or freight in an economic and efficient manner and give efficient service; this is the big nut which we must crack in educating our young men for the field of motor transportation.

I strongly recommend to Professor Trimmer, as I have done to the professors in other colleges already mentioned, that he concentrate on giving his students as much opportunity as possible to understand the science of applying motor-vehicles to transportation service. Frequently, someone in the railroad, the electric railway or the so-called independent-operating field approaches me in regard to getting a man who understands this subject, one who is experienced in this field. Professor Trimmer is doing a lot toward educating men in motor-vehicle transporation and it is good as far as it goes; but I would like to see the course carried further and the students given some of the practical side of the business. That is an acid test. No matter how much technical training a man receives in college, in the last analysis he must start at the bottom and learn the game from the ground up from the practical side.

Some applicants expect to start in a position about half-way to the top of an organization. If they are told that they must begin at the bottom at say $100 per month, they reply: "I cannot live on that. I must get $200 to $300 per month."

The motor-transport business is one of the toughest I know. One must know what he is doing and how to do it. In the last analysis practical experience is absolutely essential to success, and at least some of that phase of motor transportation should be taught in the colleges.

Operators' Attitude Toward "Cadets"

CHAIRMAN C. F. KELLS[8]:—What is the attitude of the large-scale operators as to their present practice regarding "cadet courses," naming them that? If they have not conducted those courses particularly for college-trained men, why have they not?

MR. HUGHES:—Our company has done nothing very definite toward trying to get college men into the transportation industry. I do not know just what can be done. We cooperate to some extent with Johns Hopkins University, but not in such a direct way as Mr. Hewitt described for his company in Philadelphia.

Some difficulties lie in the way. These should be recognized and handled by the managements of transportation companies; that is, by the people who control the money and the policies of the company. There should be some way of getting these technical men into the industry, but they then must have some incentive. Further, they must expect to start at the bottom, and should be made to understand this; but after having started at the bottom, there must be some opportunity to progress, both in responsibility and as to the remuneration that they receive. This is a matter that must be handled by the management, and probably it is a bit difficult.

CHAIRMAN KELLS:—Will Mr. Hewitt amplify his description of the cooperative course in his company, stating the results obtained and answering the question Mr. Hughes has raised regarding the future possibilities, and whether the positions that are offered are not sufficiently attractive to the young men?

MR. HEWITT:—The incoming students are placed in the shops as they apply and qualify, and are rated as second-class helpers. At first, the other employes wanted students to start as car-washers and greasers; but, although we wanted them to see things and get their hands dirty, we thought that was too far down the

[7] M.S.A.E.—Assistant to the vice-president, General Motors Corp., New York City.

[8] M.S.A.E.—Assistant to the president, West Penn Electric Co., Pittsburgh, Pa.

scale. Therefore, we started them as second-class helpers and paid them a special rate of 52.5 cents per hr. After these students had graduated, it is my impression that those who were selected to come into the company as cadets were paid $125 per month. These cadets work themselves ahead. They took and still take their chance with the other men in the organization, and depend upon their own ability to work and to get themselves better jobs. We do not attempt to do more than give them an entrance into our organization; after that their progress is all up to them.

P. V. C. SEE[9]:—Our company has a somewhat similar practice with regard to students. We have always employed six or seven pairs of students from Akron University. Under the present arrangement, they work six weeks in the shops and six weeks at the University. The main trouble is that, when these students graduate, in most cases we have no openings for them as regular employes even though they might have been working for us throughout their entire course. At present, I have in my employ an engineer who is a graduate of the University; but in most cases we have not been able to employ graduates.

M. F. STEINBERGER[10]:—Illustrative of the way in which some of these students approach what one might term an opportunity job: in one case, after I had notified the dean of an important engineering school that I needed two men for special work during two months of the summer vacation, a bright-looking young chap showed up. I outlined the work he would have to do and told him that he would have to work 12 hr. on some days and on others 14 hr., and that he might also have to work every Sunday. He agreed to this. Out of curiosity, after I had decided that he would be acceptable I said: "Now young man, how much do you think the railroad ought to pay you for this particular work?" He replied, "I wouldn't work for anybody for less than $300 per month." My answer was that he would have to be with the railroad a long time before he could get $300 per month. I fear that this is the attitude in which many students approach the opportunities that come their way.

In another instance we tried to choose some men as carefully as possible and found that one difficulty was a somewhat superior attitude on their part. We employed some of them on the platforms where they were supposed to do truck-freight work, but they did not want to get callouses on their hands. They spread the impression that they were simply in a temporary position and that they soon would be bossing the other men. This attitude created considerable confusion and discontent and the plan did not work out well. If in some way the college students could get the right attitude toward work firmly established, that is, that they expect to start at the bottom and take their chances with the other men, I think they would progress more rapidly and would be promoted much more quickly.

H. B. HEWITT

B. J. LEMON[11]:—We have had somewhat the same experience with university students. Numerous pairs of them work in our factory. In one case in which we wanted a man in the aeronautic department, we interviewed eight students. Five of them were acceptable to us from the basis of the course they were taking in the university, but we found that our work was not acceptable to any of the students. The job was one of following tires through the plant and calling upon the aeronautical trade. It was a good job, but did not pay much to start with. It was not a dirty job and has since developed into a very desirable job; but at that time it was not acceptable to the students. I feel that students are not willing to start at the bottom and work their way up by promotion; and that they do not want to do what everyone else must do to get a start in any branch of any industry.

The student to whom I refer is the student who spends part of his time in industry and part in college. In industry he meets men who are doing mechanical work and who are receiving high wages. When such a student graduates from college, he rather expects to step up to that high wage-rate. I think that students who spend four years in a university are willing after graduation to start in at a wage lower than that which is expected by the student who has spent part of his time in the industry and has learned that good workmen can earn large wages.

PROFESSOR TRIMMER:—Mr. See has stated that he had students from the University of Akron working in his shop, but he did not say whether the students were good workmen or not. Further, he said that after these men completed their university course, he had no definite position to offer them. Mr. Horner mentioned that men who understand transportation are not available; but, after communicating with several branches of the General Motors Co. and having their representatives come to the Institute and look over our prospective graduates, one representative asked a student: "Are you a finished automobile mechanic?" Of course the student answered "no," and was told by the representative "then we do not want you."

Applications were sent to Mr. Hewitt's office in Philadelphia, and the reply received was to the effect that "our course is all filled up. We will put your name on file. When there is room for you we will call on you." That was four years ago and there has been no call from that source since.

I think that, to a great extent, the trouble with the maintenance and operating executives is that they do not want to employ anybody until they actually want them, and then they want the men at once. In other words they do not propose to spend any money training a man for a certain job.

Replying to Mr. Lemon and Mr. Steinberger, I know that some college men want say $300 per month as a beginning wage, but they are disillusioned very quickly and soon come to their senses. I tell my students that they must start at the bottom and work up, and that no president of any company expects to resign just because they are graduating. If the maintenance and operation executives had a definite training-program

[9] M.S.A.E.—Vice-president and general manager, Akron Transportation Co., Akron, Ohio.

[10] M.S.A.E.—Manager of highway transportation, Baltimore & Ohio Railroad Co., Baltimore, Md.

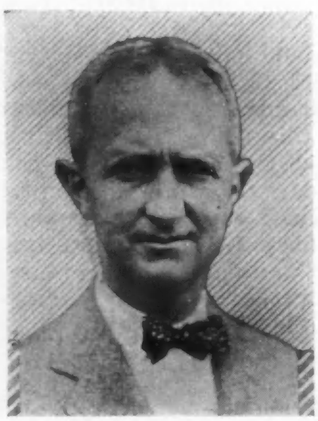
[11] M.S.A.E.—Field engineer, United States Rubber Co., Detroit.

laid out and would take these students and give them a chance, in the long run it would be a paying proposition.

Many companies send representatives to the Institute to look over our prospective graduates, to talk with them later, to take them into their organizations and fit them for future positions in that particular organization. Some of the large-scale electrical manufacturing companies and similar rubber-manufacturing companies have apprenticeship courses for college graduates where they train these men and give them an opportunity to obtain a bird's-eye view of the business, and then the company fits them into some particular job. Such men are trained and available when they are wanted. Why not take the graduate students into your own organization and train them to fit into some particular job?

MR. HORNER:—I think that Professor Trimmer and I are talking at cross-purposes. He is talking about the technical side of this matter. I am talking about the practical operating side of motor-transport, which is another matter. I shall cite two examples of men in the passenger and in the freight-operating or practical sides, which will show Professor Trimmer the picture that I am trying to present.

In one instance a man who was a conductor on a motorcoach for a large company had what Frank Pick, of the London Omnibus Co., calls "common sense" which, after all, is a scientific use of the imagination. Besides taking in fares and watching the passengers get on and off, he observed other things that were going on and, at night, he used to write out his thoughts. Finally, he made these into thesis form and submitted it to his official superior. The superior read the thesis and was so much interested that he passed it on; and eventually it reached the chairman of the Board of his company. The last mentioned was so profoundly interested in the observations made that he transferred this man to special work in his own office. This man was sent to make certain surveys and to bring back all necessary information. This he did and did well. Today he is in charge of motorcoach and motor-truck operations, with special reference to the application side of the business for one of the largest automotive companies in the export field. He was possessed of very little education and had no technical training; but he had imagination, observed as he progressed, and finally attained the necessary knowledge of the practical side of the business.



F. C. HORNER

The other example is that of a man who was running a very large freight-handling motor-transport operation in this Country. He is a self-made man, is wealthy, and his transport operation is conducted in a scientific way. His son was a graduate of one of the large colleges and wanted to enter his father's business. Asked, by his father, concerning the best means of introducing the young man to the business, I replied that I would start him on the freight platform, as a helper on the trucks, would "give him the gaff" and let him understand from his own experience what the business was all about and give him a background of knowledge of the other fellows' problems before taking him into the office. Then I remarked that if the applicant had this background he could work out intelligently the solution of executive problems. This young man's father agreed with me and that policy was adopted. The young man naturally did not much relish the idea; but he was a good soldier and today he is assistant manager of the company after having worked hard for five years to qualify.

I do not mean to criticize these young men who come out of the colleges, and there is nothing that I would rather do than to help a young man get started in business; but I certainly do not relish the idea of trying to help a man who expects to start in a position that is higher than it is sensible for him to expect that he can fill.

This motor-transport game is a very big proposition and covers a tremendously large field. It is a very fertile field for these young men who graduate from the colleges. They have a great opportunity of learning how to apply this motor-transport tool to transportation requirements, and then going out into the field and doing it. But it is not merely a game which lasts from 9:00 a. m. to 5:00 p. m. daily; it is often continuous for 24 hr. We can get men who are qualified mechanically, but even this is not very easy. I will challenge anyone to show me that any great number of men are available who understand the application of motor-vehicles to the science of transportation; but we certainly need them.

J. F. WINCHESTER[12]:—I am greatly interested in this subject because of having been directly connected with the operation of motor-vehicles for seventeen years. Much of the trouble that is experienced in obtaining satisfactory employes perhaps rests upon the men who are making the selection rather than upon the men whom they sometimes select.

In these seventeen years that I have been connected with our company the automotive department has employed a large number of men. The company's policy has always been a very liberal one toward labor, as well as in regard to the education of the men. But the policy has always been to endeavor to select at the start men who are physically, mentally and by training equipped to handle certain specified work. In the period specified I cannot remember more than, say, twelve men that I have been forced to discharge. Some of these were college men who had come to us for fundamental training.

In considering students, two different types of men attend school today. It is not to be wondered at that those whose fathers have plenty of money and who have been brought up in a fine home, amidst fine surroundings, want several hundred dollars per month as income. On the other hand we find a certain group of men who are plugging all the time and earning their own way through the schools. That is the type of man whom I have selected during summer vacations and have endeavored to have them come back year after year until they were graduated; then we employed them. That type of boy is usually more mature; he has greater responsibilities and seldom fails.

[12] M.S.A.E.—Superintendent of motor-vehicles, Standard Oil Co. of New Jersey, Newark, N. J.

Concerning our procedure with these men after they become members of our force, those who are inclined to stay with us have openings for promotion. We have used them in different positions as related to the operation of motor-vehicles.

In some instances these men have become executives, or what we term "branch superintendents." In other cases they have entered some side line as regards motor-vehicle operation, but which is really an important line with the company in that it consists of selling the product to the general public.

We feel that the general public is one of the largest-scale fleet-operators that exists. By training the men referred to in the ways and means of operating motor-vehicles so that they can go out and sell the product, they have not only fundamental training and knowledge as regards the application of the motor-vehicle, but also they know how to have proper appreciation of the products we manufacture.

Regarding Mr. Horner's remarks concerning the fact that very few men understand the scientific application of the motor-vehicle and the problem with many as to how to find such men. I wonder just what constitutes scientific application; that puzzles me, and particularly so when I hear so many conflicting opinions from experts on a given subject.

The electric-railway men say that they would like to promote men from the inner personnel because they are revenue producers. I know of no industry that has complained more during the last ten years than has the electric-railway industry because of inability to get sufficient revenue. Perhaps, if the electric-railway industry obtained men of a different type, these men would be equipped with a different viewpoint and the revenue would be much greater than it has been through promoting the practical men, who may be outlook-stunted because of their narrow training.

I am in sympathy with the present-day tendency to train men to operate motor-vehicles. The picture is changed. Over the period including the last several years it was necessary to have practical men who were promoted from the shop, because the number of mechanical problems was much greater than is true today. At present, we are dealing more with the scientific analysis of what is taking place within the vehicle. To understand that phase thoroughly, in many cases it is necessary to have men who have received the fundamental training that is given in schools and colleges.

Wear Tolerances on Gages

(Concluded from p. 214)

On the subject of distortion: If there is necessity that a part should be round after it is finished, gaging should check that point. If, however, this is not necessary, some other system of gaging can be devised. Ordinary gaging may not detect an out-of-round condition; for instance, an ordinary heart-shaped cam has all its diameters equal, yet it is far from being round. Wires used for measuring thread-gages frequently are found to be 0.0001 in. out-of-round, and this error is multiplied by the conditions under which they are used so that it results in a considerable error.

Since Not Go gages wear out much less rapidly than Go gages and since variations in their dimensions often have critical effects on fits, economy and efficiency will be best served by making the tolerance on Not Go gages exceedingly close, and on Go gages more liberal.

Discussion of J. S. Lowe's Transportation Meeting Paper[1] on Driver-Training for Maintenance Cost-Reduction

A SERVICE School designed to aid the inspectors and motor-vehicle drivers of his company's motorcoaches was described by the author. The men were told that their attendance at the School was compulsory, and that they would learn things that would be beneficial to them in whatever type of life endeavor they might decide to pursue. Lessons were given twice daily and drivers were required to attend at least one session each week for 20 weeks. The men attended on their own time, and previous experience was not considered. The course was given to drivers who operated their vehicles unaided.

After describing the details of the lecture form of instruction that was given, citing examples of the type of instruction, the author stated the conclusions which were reached as a result of this conference method of training and analyzed the statistics which were obtained. A further outline was given as to the method whereby instructors were selected.

In the discussion following the paper, Mr. Lowe answered in detail various questions which related to the kind of training provided for drivers after they leave the School, the effect of the discontinuance of street-cars in Akron on the records of the drivers, how drivers are controlled outside of the School and on the road, and the practices with regard to drivers in relation to the number of accidents charged against them. In respect to disciplining drivers he said it is the company's endeavor to retain every employe whom it is possible to retain, and he gave an explanation of the unusual situation in Akron which affects the labor turnover on account of the irregularity of drivers' working-hours.

Mr. Lowe gave further details as to the management of the drivers' School in respect to examinations and items which affect a driver's record as regards the honor roll and the medals given for good service, outlined the procedure used when accidents occur and, in general, carried out his previous statement that he wished to present in its broadest aspects the company's viewpoint regarding the training of drivers.

J. A. HARVEY[2]:—What sort of training do you provide for drivers after they leave the School?

J. S. LOWE:—As the curve of human memory is decidedly downward, we give the men periodic reviews on subjects that are most essential for the operation of the property. The instructor devotes about 4 hr. per day to instruction in the classroom; the balance of his time is occupied in riding in the vehicles and instructing the drivers.

B. J. LEMON[3]:—Did the depression in the Fall of 1929 and that of 1930, the consequent unemployment and the discontinuance of street-cars in Akron, Ohio, and the fact that the drivers may have felt more satisfied with their jobs when other people were out of work, have any effect on their record?

MR. LOWE:—Our chart indicates that very clearly by the low labor-turnover. It is true that these factors have had some effect, and it will be difficult to overcome when conditions change.

A. F. COLEMAN[4]:—All operators are interested in accident prevention and all are striving to lower the accident rate. We have not been as entirely successful in this regard as we desire to be. What, if any, was the compensation given to the drivers who successfully completed one, two, three or four years, in addition to the gold medal mentioned? Will you follow through in greater detail how drivers are controlled outside of the School and on the road? Even with all the training and instruction that can be given them, one cannot turn drivers out on the street and expect to reduce accidents by that method alone.

MR. LOWE:—Answering the first question, we present the men with a gold medal at the end of one year for preventing accidents and for the succeeding years a different type of medal until, at the end of the fifth year, a $20 gold piece is given; but without raising the hourly rating of the driver during his service. We also have safety contests quarterly. Men who are free from an accident for three months are given a banquet, at which some member of the management talks to them and other features of interest take place. The men appreciate this very highly.

Regarding the follow-up system, particularly concerning accidents, six full-time safety-supervisors devote their entire working periods to riding in the vehicles, checking up on the drivers and instructing them. Periodically, men check up on the drivers as to the way in which they handle the vehicle in regard to its mechanical parts, and they look for any tendency toward abuse of the equipment. They also observe whether or not drivers are taking advantage of the training they have received, in addition to having the School instructor devote half his time to that purpose.

B. H. EATON[5]:—What constitutes an accident in which the driver is charged with that accident?

MR. LOWE:—We have no so-called non-chargeable accidents. In keeping the records of the men, we note whether or not the man is responsible for the accident. But, even so, in driving down the street, if he makes a regular service-stop to take on or discharge passengers

[1] Published in the S.A.E. JOURNAL for November, 1930, p. 591. Mr. Lowe is general superintendent of transportation, Akron Transportation Co., Akron, Ohio. For the convenience of readers, a brief abstract of the paper is printed herewith, together with a statement of some of the major points brought out in the discussion.

[2] M.S.A.E.—Operating engineer, Pittsburgh Motor Coach Co., Pittsburgh.

[3] M.S.A.E.—Field engineer, United States Rubber Co., Detroit.

[4] M.S.A.E.—Manager, motor-vehicle department, Standard Oil Co. of New York, New York City.

[5] M.S.A.E.—Motor-vehicle supervisor, Bell Telephone Co. of Pennsylvania, Pittsburgh.

and somebody collides with his vehicle in the rear, he loses the chicken dinner and the gold medal at the end of the year. We find that if drivers watch the rear-vision mirror, they can prevent hundreds of that type of accident.

MR. EATON:—Who makes out the detailed accident report?

MR. LOWE:—The driver makes out the report. It is then turned in to the dispatcher, who checks over the report to see that it is properly filled in and, if found correct, he sends the original copy to the claim department, a duplicate copy to the accident-prevention department, and the triplicate copy to the division superintendent. The division superintendent summons the man, discusses this accident across the deck with him regardless of how minor it may appear to be, asks if he has any suggestion that would prevent a recurrence, and so forth. Where praise is due, the driver will receive it; where discipline is deserved, he also receives it.

THOMAS C. FRASER[6]:—Would Mr. Lowe penalize a driver if a motorcoach should stop and if two other cars collide and jam into the motorcoach? Would the driver's accident record be spoiled?

MR. LOWE:—If a driver has an accident, this deprives him of the privilege to participate in the awards.

MR. FRASER:—But the driver could not escape if his motorcoach were standing still and the other two cars collided and bumped into the motorcoach. Yet you say that he would be deprived of his privileges.

MR. LOWE:—Yes.

JOSEPH HUSSON[7]:—In my opinion, that practice is wrong. The point I wish to emphasize is whether this expensive driver-training should be wasted when a driver has perhaps one serious accident or several minor ones. How do you obviate the economic loss caused by training a driver and then removing him from your service when he has been careless?

MR. LOWE:—In respect to disciplining drivers, we try to retain every employe it is possible to retain. We consider that a new man is always a risk to our organization.

We have an unusual situation in Akron, which affects the labor turnover due to the irregularity of service hours. The large rubber-industries operate on 6-hr. shifts, the beginning time being midnight, 6:00 a. m., noon, and 6:00 p. m. Their office staffs work from 8:00 a. m. to 5:00 p. m. The employes in the Zeppelin plant work from 7:00 a. m. to 3:00 p. m. To enable the drivers who operate the daylight routes to attend the School, it opens at 4:00 p. m. Drivers who operate the night routes attend the School at 10:00 a. m.

CHAIRMAN C. F. KELLS[8]:—Maintenance costs are so susceptible to change from various causes that it might be somewhat unfair to say that, when considered in the reverse order, the change of maintenance cost per mile indicates completely the effect of this. Or, there may be changes brought out by things entirely aside from the driver training. I think that "pull-in" record and "disabled bus" records might readily show it.

Is a written examination required at the end of the course, or is it oral? If oral, who hears the examination?

MR. LOWE:—In respect to the pull-ins, I might have given a lecture devoted entirely to the mechanical features; but the intent was to give a broad idea of what we are endeavoring to do in the training of the drivers. We have a record of the pull-ins, and also have a record of the defects. We have followed the suggestion made here that all details had not been enumerated on the defect sheet, and that the sheet should be left blank so that the operator can write in what really is defective. Since we began schooling the drivers, it is astonishing to note how closely the defects reported coincide with what the mechanical department really finds the condition of the coach to be.

The examinations are written. Reviews are given in the lectures. After about every seventh lecture, a written examination is held. It tends to key the men up for the final examination, which also is written.

PAUL P. PIERCE[9]:—How many of the original men who first received these gold medals are still in your employ?

MR. LOWE:—I cannot state the percentage of original employes who are still employed, but it is a high percentage. Some men quit on their own initiative, and some men are disqualified for other causes.

Bonus System Discussed

MR. PIERCE:—How much more accident prevention would you obtain if the bonus system were employed? Would it not be better to give the men more of an incentive that would stimulate them each day, instead of presenting only the gold medal?

MR. LOWE:—There is a certain danger in the application of the bonus system. There is a danger in the system we now have in force, small as it may be. We find that some men have a tendency to cover up accidents. For example, a driver may bend a fender on an automobile, get out of his vehicle, ask the automobile driver what the damage will cost, and attempt to pay cash to settle the damage on the spot. In other cases, the automobile driver may say that it was his own fault and that our driver need not bother about it, and then the driver does not make out a report. In other cases a driver may say to the automobile driver, "I have not had an accident for 360 days and if I can get by for another 5 days I will get my award. I hope you will not report me unless you consider the damage is great." The larger the bonus is, the greater is the tendency toward unreported accidents and the more difficult it is for a claim department to make an adjustment.

A. H. GOSSARD[10]:—In two of our branch localities we pay a bonus of $2.50 per month for each month that a driver is free from having had an accident, and this has produced good results. Generally speaking, dealing with accidents in a drastic manner has produced better results. When a driver has an accident, in numerous companies he is automatically removed from the payroll until such time as he can prove that the accident was not his fault. This is generally established by witnesses whose names the driver secures at the time of the accident, and this has a tendency to eliminate any attempt to cover up an accident.

MR. LOWE:—In the event that you find a case in which the driver was not at fault what do you do?

MR. GOSSARD:—The driver is not necessarily relieved from service, but his name is taken off the payroll. Generally, a driver will prove in a hurry whether the

[6] M.S.A.E.—Superintendent, motor equipment, Standard Oil Co. of Pennsylvania, Philadelphia.

[7] Transportation Engineer, Vacuum Oil Co., New York City.

[8] M.S.A.E.—Assistant to the president, West Penn Electric Co., Pittsburgh.

[9] M.S.A.E.—Engineer, Vacuum Oil Co., New York City.

[10] M.S.A.E.—Manager, automotive department, Middle West Utilities Co., Chicago.

accident in question was his fault or not. Most of such cases can be decided very quickly, and the driver loses no pay if the accident was not his fault.

MR. LOWE:—In that connection, we do not relieve a driver because of a minor accident; but if it is a serious accident in which a possibility exists that the driver is at fault, he is relieved from duty. In the event that the driver was not at fault, we compensate him for the time lost.

JAMES W. COTTRELL[11]:—Do you count it an accident that affects the driver if a passenger is hurt while getting on or off a motorcoach while it is at a standstill? Do you charge against the driver an accident which is plainly caused by a defect in the vehicle?

MR. LOWE:—We do not have non-chargeable accidents.

Mechanical Defects Exonerate Drivers

P. V. C. SEE[12]:—Referring to Mr. Lowe's previous statement, if the brakes were defective, the driver would not be penalized. That is, if a brake-rod broke or if a test of the brakes showed that the pressures were insufficient, we would immediately admit that the accident was due to failure of the shop to provide an adequate braking-system and the driver would not then be penalized. With regard to the number of road calls for service and pull-ins of dead motorcoaches, a very marked decrease is evident since the drivers' School began.

HENRY A. ROSENQUEST[13]:—Is the work of the School continuous throughout the year, or does it end after a certain period?

MR. LOWE:—The School is not continuous and depends for its continuity upon the number of employes who enter our service. If a new man is employed, he begins the School work immediately.

MR. ROSENQUEST:—Is a driver informed that he must attend the School after he is employed, that it is compulsory and that he must attend the School on his own time?

MR. LOWE:—Yes. I do not know of a single instance in which an applicant refused to become an employe because of the foregoing reasons.

MR. LEMON:—If a driver has frequent difficulty due to curb scuffing of tires against the street curbing, is a penalty inflicted on him?

MR. LOWE:—We have some difficulty due to curb scuffing and frequently reprimand the driver severely; but, on the contrary, the accident-prevention department also reprimands drivers for getting too far away from the street curbing. However, they are not suspended.

MR. LEMON:—How frequently are dual tires injured because of objects that lock between them?

MR. LOWE:—The percentage is very small.

H. B. HEWITT[14]:—How far does instruction go in the mechanical department?

MR. LOWE:—We have not applied the schooling to the garage or shop employes in that respect. Our School is a driver-training feature.

Other Practices Regarding Accidents

MR. HEWITT:—We have a plan by which the motorcoaches move between the garage and the shop. They are moved by the repairmen in the shop. In many cases, a repairman can take a coach with him on his way home and deliver it to the garage. We, therefore, have a certain number of qualified drivers in the shop force who attend the same School as do the drivers who do nothing else but drive. These shop men are also used on holidays as auxiliary drivers. The shop is closed on Saturdays and Sundays, and we have peak needs then for drivers. These men wear a uniform cap and serve as regular drivers.

MR. LOWE:—During our busier seasons, such as the holiday seasons, we put extra drivers in the garage to answer road calls. For instance, suppose we have a disabled vehicle that needs replacement, we send an extra driver out with a coach to pick up the schedule en route so as to lessen the inconvenience of our patrons.

E. A. CLARK[15]:—Do you have any trouble in getting truthful statements from your drivers regarding accidents, or in having drivers get witnesses of accidents?

MR. LOWE:—I think the average individual is honest, but we do have some cases in which we have to "sweat out" drivers to ascertain the truth of their statements; sometimes we cannot get at the truth even after this, but must obtain the information from outside sources. However, such cases are rare, and they are much more rare now than before we started the School. The schooling creates a better understanding in the minds of the drivers.

Our drivers are usually successful in obtaining witnesses. One point stressed in the schooling is that a driver never should ask any person whether he has seen the accident, because the only two direct answers possible are "yes" or "no" and the questioner invariably gets the answer "no." Instead, drivers are instructed to say "it will be necessary for me to make out an accident report, and if you will kindly give me your name and address it will be of great assistance to me." In other words, the appeal is made personally by the driver instead of being made for the company.

E. W. JAHN[16]:—What have utility operators who do not operate motorcoaches done in connection with the training of motor-vehicle drivers such as salesmen? Our company operates 300 passenger-cars and about 200 motor-trucks. For instance, if a man becomes a shining light in the sales force and the company wants to send him out into its territory, such a man must be taught to drive a company car.

MR. ROSENQUEST:—When we employ a new man, say in the sales division, we have one of our vehicle inspectors give him a road driving-test. If he passes the road test we have lined up for him, the car is turned over to him for his use. If he has no driving experience, we train him for about three weeks and then send him to the city's motor-vehicle bureau for examination. If he passes that examination, then a report is sent to his department which states that he has passed all the requirements, and the car is then assigned to him.

Educational Plan Cited

PIERRE SCHON[17]:—Mr. Lowe's charts show that total operating-cost per mile has been reduced considerably

[11] A.S.A.E.—Technical editor, *Commercial Car Journal*, Chilton Class Journal Co., Philadelphia.

[12] M.S.A.E.—Superintendent of equipment, Northern Ohio Power and Light Co., Akron, Ohio.

[13] Superintendent of stores and transportation, The Bronx Gas & Electric Co., New York City.

[14] Philadelphia Rural Transit Co., Philadelphia.

[15] Superintendent of automotive equipment, The Rieck McJunkin Dairy Co., Pittsburgh.

[16] M.S.A.E.—Superintendent of transportation, Consolidated Gas, Electric Light & Power Co. of Baltimore, Baltimore, Md.

[17] M.S.A.E.—Sales engineer, General Motors Truck Co., Pontiac, Mich.

on a total mileage of 15,000,000 miles per year. Savings in accidents for the first seven months of 1930 are represented as $67,802.16. I think that is a remarkable showing and I believe its success is based, primarily, on training drivers.

The training of commercial motor-vehicle drivers is a very serious problem. The Akron Transportation Co. has demonstrated that driver training pays handsome dividends, and no phase of the transportation business presents greater opportunities for lowering costs than proper training of drivers in the operation of motortrucks and motorcoaches. The picture Mr. Lowe has presented is certainly worthy of study by many operators.

Calling attention to the educational campaign being conducted by the National Automobile Chamber of Commerce, other dividends can be derived from drivers' training. This educational campaign, instituted by the N. A. C. C. and financed by the manufacturers, incorporates a program of education for the operators to caution their drivers, calling their attention to the results of careless driving on the road.

If such good results as cited by Mr. Lowe can be obtained in city operation, the same principles can be applied to long-distance operation. Many of our laws today are antagonistic to the operation of motor-vehicles, and part of this situation has been brought about by careless driving. Right now, a very serious case is pending in the State of Missouri, where the carelessness of a truck driver resulted in strict enforcement of the laws governing the size of vehicles. The objective of the educational campaign conducted by the N. A. C. C. is paving the ground for securing more reasonable and uniform legislation.

Drivers' training is one of the most important activities operators can initiate to assist in this campaign, so that more uniform and more reasonable legislation can be obtained.

[15] Superintendent of transportation, Pittsburgh Motor Coach Co., Pittsburgh.

MR. LOWE:—As previously stated, I wanted to present a broad idea of what we are endeavoring to do in the way of training drivers. Perhaps I should have confined the paper entirely to the mechanical features, but the lectures given in the mechanical, safety and transportation courses are compiled in booklet form, are available, and can be had by writing to me.

MR. COTTRELL:—Is there any reason for having that School for driving instruction rather than for mechanical instruction?

MR. LOWE:—We feel so. I made investigations all over the country. On most properties they make a particular effort to teach the new employe in service everything they possibly can before he is permitted to drive alone. We do not believe in that policy. When we employ a driver he has to meet the medical qualifications, pass the required tests in different respects, give references, and so on. Then he is put out on what we term the "School motorcoach" with an instructor, and he stays there for a week, driving the different kinds of equipment. If he cannot qualify in 10 days, he is not permitted to continue. But we feel that, should we attempt to try to cover all the subjects all the time while the man is learning other things, we would be unsuccessful.

R. C. GILMORTIN[15]:—Is that School motorcoach used in passenger service, or does it run without passengers?

MR. LOWE:—The School motorcoach is operated in outlying districts. After the student drivers become very familiar with operating the vehicle in outlying districts, they are given training in the more congested districts and are taught to the point at which they are very efficient before they are even permitted to go out on the line with other drivers who carry passengers. They are given accurate and complete training on the School motorcoaches. They are required to put in a specified number of hours, a certain number in the day time and a certain number at night, with regular operators over the various routes.

The Effect of *Time* on Production Cost

Production Meeting Paper

By Paul N. Lehoczky[1]

THE SAVINGS made possible by using economic lot-sizes are discussed by the author, who also presents formulas and their practical application for estimating purposes in the field of drop forging, foundry work, purchasing, stores and supplies, as well as how these may be applied in measuring managerial efficiency. After stating the direct method, which is to obtain the lowest cost, he mentions *Time* as a noteworthy factor of the indirect method, which includes decreasing the time required for doing one or several operations, decreasing the time of material tie-up, increasing the number of turnovers and reducing the capital investment.

Time also is the basis of all efforts of a relatively new type; that is, efforts along economic production-lot sizes, purchasing quantities, labor management, seasonal production, seasonal sales-distribution, and all efforts that can be classified under the general head of production-time economics. A general formula is then developed, values of several special cases are substituted and in each supposed case solved. The results obtained are then discussed at length, comparisons being made. In conclusion, the statement is made that this type of analysis can be used whenever capacity is greater than production, especially if the equipment can be used for other purposes than the one in question.

In the discussion, the practices followed by several companies are outlined and comments made on details of the formulas with regard to the variable factors.

TO OBTAIN the lowest cost and to cut costs constitute one of the chief aims of the production man. He has tackled the problem in a variety of ways, the most obvious of these being by the substitution of more economical materials wherever possible, perhaps because they cost less, directly, and perhaps because they have better qualities and hence reduce cost indirectly.

The second most noteworthy method in cutting costs is an indirect one and involves the factor *Time*. Decreasing the time required to do one or several operations, decreasing the time of material tie-up, increasing the number of turnovers and cutting capital investment, all depend indirectly upon *Time* as a fundamental basis and upon the value of this time. The same factor is the basis of all efforts of a relatively new type; efforts along economic production-lot sizes, purchasing quantities, labor management, seasonable production, seasonal sales-distribution, and all efforts that can be classified under the general head of production-time economics.

The aim of this type of analysis is to ascertain what one's costs are in any particular field, what the lowest possible cost is and, what is more important, by what arrangement the lowest cost can be obtained. The fact that this analysis tells one just what the lowest cost is enables one to measure the efficiency of any particular function in a plant. The analysis in any given case depends on the factors as they are in fact, and gives the low-cost combination of these factors with respect to time. If any of the factors fundamental to the analysis —as, for example, the price of raw materials—is changed, then a corresponding change will have to be made in the lowest cost-arrangement.

Since any analysis, and especially one subject to frequent changes, is elaborate, the easy way out is to develop a general analysis which gives a general solution, substitute the values of the special case in the general formula, and then solve the formula.

Economic Lot-Sizes

Let us consider one of these types, economic lot-sizes. This is dependent on what is commonly termed "inverse relationships," which means that what is a favorable condition or arrangement for one of the factors is a very unfavorable one for the others. As we change the arrangement to suit the second factor we lose some of the advantage in the first, gaining at the same time in the second. One can think of this as a balance which can be brought into equilibrium only if the weights on both sides are equal.

We want to produce a product and know approximately how much of it we will need during the year to come. Disregarding seasonality, our capacity is much greater than the amount to be produced, so the question arises: How shall we distribute our production? Shall we produce the whole amount with one set-up; shall we use two set-ups, one now and one six

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months hence; shall we use 3, or more, up to 12 set-ups? If we produce everything on one set-up then there will be but one set-up charge, certainly a favorable condition for this factor. On the other hand we must buy all of our material at one time and, since we sell the product uniformly throughout the year, there will be a considerable waste in interest and storage charges, not to mention the relatively large capital-requirement.

Regarding the other extreme, suppose we decide to cut down on our capital requirements, on interest and on storage charges, hence producing the product as needed every month. But this involves 12 set-ups, which is a very unfavorable condition so far as this cost factor is concerned. The question then arises: What sort of an arrangement will give the lowest cost considering both factors? This is what a suitable economic lot-size formula tells us. As formulas go, this one is not very complicated, but it causes trouble because it does not show the intermediate steps and the reasoning. The formula represents merely the generalized process for solving any problem. Anyone who solves a specific problem goes through the same steps, and sometimes many more, except that actual figures are used instead of general terms. We will consider a simple case, involving but two opposing factors, and analyze it.

Application of the Formula

Assigning values to the various factors: S indicates the cost of one set-up, for the special case, \$150; I represents the current interest rate, or 6 per cent. N is the number to be made in the given year, which, in our case, is 30,000. C represents the cost per piece, or \$3. In a more thorough analysis the factor C would need to be qualified with reference to raw and to finished cost; but, in this example, we will assume C as representing finished cost for the sake of simplicity. The question then is: What will be the lowest cost of producing the piece and what is the production-time arrangement for this low cost? The answer is contained in the following analysis.

If the entire quantity is to be produced at once, the cost will be:

$$\text{Cost (1 set-up)} = S + (N\ C \times I) \qquad (1)$$

The set-up cost, S, is \$150, but the interest-charge computation $(N\ C \times I)$ needs explanation. If we were to keep our capital tied up for the entire year, a simple multiplication of capital by interest rate would give this factor. But we sell the product uniformly throughout the year, so that some of our capital is released almost immediately after the product is finished. By the time six months have elapsed, one-half of our product has been sold; hence, one-half of our capital has been released. As the year goes on, more and more capital will be released so that, theoretically, at least, there will be no capital tied up at the end of the year. Therefore, the interest on the average capital tied up must be taken, which, in our case, is 0.5 and is represented by A, the "averaging factor."

$$\text{Cost (1 set-up)} = S + (N\ C \times A \times I) \qquad (2)$$

For the special case we have, by substituting values,

$$\begin{aligned}\text{Cost (1 set-up)} &= \$150 + [(30{,}000 \times 3) \times 0.5 \times 0.06] \qquad (3)\\ &= 0150 + \$2{,}700\\ &= \$2{,}850\end{aligned}$$

Suppose the set-up is made twice a year. The set-up cost S will be doubled, but the interest charges will be cut one-half. First, there will be but one-half the number of pieces in each set-up, thus reducing the capital investment one-half. Second, the interest on this capital is effective only for six months, even if it were all used throughout the six months; but, according to the foregoing reasoning, the averaging factor A must be applied to balance gradual sales. Finally, since we are basing our total cost on the yearly basis, we must multiply by 2 because there are two set-ups. So we have:

$$\begin{aligned}\text{Cost (2 lots)} &= 2\ S + (2 \times 0.5\ N\ C \times A \times 0.5\ I) \qquad (4)\\ &= 2\ S + 0.5\ (N\ C\ I/2)\end{aligned}$$

For the special case we have, by substituting values,

$$\begin{aligned}\text{Cost (2 lots)} &= (2 \times \$150) + [2 \times 0.5 \times (30{,}000 \times 3)\\ &\quad \times 0.5 \times 0.03] \qquad (5)\\ &= \$300 + \$1{,}350\\ &= \$1{,}650\end{aligned}$$

If coutinuing the analysis by the roundabout method, we would find costs for 3, 4, 5, or more set-ups and then choose the lowest cost-combination. The formula avoids this; it gives the low-cost combination immediately, without solving for a large number of cases. To show how this formula is derived, let us substitute the letter X for the number of set-ups. Then we have, for any number of lots, from the previous formulas:

$$\text{Cost } (X \text{ lots}) = S\ X + (N\ C\ I\ /\ 2\ X) \qquad (6)$$

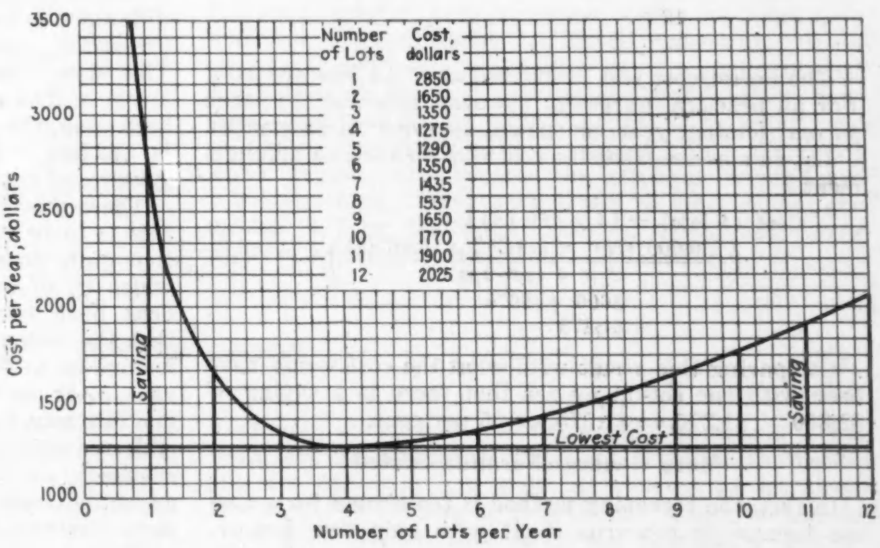

FIG. 1—COST, WITH VARIOUS SET-UP ARRANGEMENTS

Further Development of the Method

If we use specific figures, we would need to repeat the foregoing process every time we solved this formula for a different set of values. But if we do this and plot the results, using costs as ordinates and set-ups as abscissas, we would obtain the curve shown in Fig. 1, which shows the cost with various set-up arrangements. The point we wish to find is the low spot, so far as cost is concerned; that is, the lowest cost-arrangement. Since the general equation represents a curve, we can use differential calculus to determine

this low spot without any substitution or plotting. Differentiating the equation once will give the slope of the tangents to any point, and the slope of the tangent to the low point is 0; that is, this tangent is horizontal. Hence, we have:

$$\text{Cost} = S\,X + (N\,C\,I\,/\,2\,X) \tag{7}$$

Differentiating and equating the tangent to O we have, since

$$X\left(\frac{dy}{dx}\right) = 1 \text{ and } 1\,/\,X\left(\frac{dy}{dx}\right) = \frac{1}{X^2}$$

the following equations.

$$0 = S - (N\,C\,I\,/\,2\,X^2) \tag{8}$$

$$(N\,C\,I\,/\,2\,X^2) = S \tag{9}$$

$$2\,S\,X^2 = N\,C\,I \tag{10}$$

$$X^2 = (N\,C\,I\,/\,2\,S) \tag{11}$$

$$X = \sqrt{(N\,C\,I\,/\,2\,S)} \tag{12}$$

Equation (12) indicates that the lowest cost-combination is the one that involves the given number of set-ups, by substituting the values therein. For our specific case:

$$X = \sqrt{\left(\frac{30{,}000\ (N) \times 3\ (C) \times 0.06\ (I)}{2 \times 150\ (S)}\right)} \tag{13}$$

$$= \sqrt{18}$$
$$= 4.2.$$

The lowest cost will be arrived at if 4.2 lots are used. For all practical purposes, however, this may be taken as four lots per year, or one set-up every three months.

Let us now see what the cost is with such an arrangement.

$$\text{Cost (4 lots)} = [4 \times 150\ (S)] + \left(\frac{[30{,}000\ (N) \times 3\ (C)] \times 0.06\ (I)}{2 \times 4\ \text{(set-ups)}}\right) \tag{14}$$

$$= \$600 + \$675$$
$$= \$1{,}275$$

Comparing this result with what the cost would have been with one set-up we see that there is a saving of $2,850 − $1,275 = $1,575, or 55 per cent.

More General Formula Stated

In fact, the foregoing method is too simple for actual use because it concerns itself with only two factors, capital and set-up cost. A more general formula suitable for use is:

$$X = \sqrt{\left(\frac{N\,C\,I\,(J + L - L\,J) + S_t}{2\,S}\right)} \tag{15}$$

where

C = cost per piece of material (raw)
I = interest rate per year
J = ratio of output to capacity, the output being N pieces per year
L = ratio of cost of finished product to cost of raw material, the factor taking into account the value added by the work done to the piece
S = set-up cost for one set-up
S_t = cost of storing the finished product in dollars per piece per year
X = number of lots to be used during the year

These factors were chosen because they are the most prevalent in the average company. For any particular company a special formula can be worked out that omits some of the unimportant factors and includes others peculiar to that industry. For example, we may include such factors as spoilage due to storage, depreciation, the chance of obsolescence, and the like. The formula in such a case would be similar to the one given, but would contain the special factors mentioned in some form or other under the radical sign. For any particular plant it would be best to work these out separately rather than to use a highly complicated formula which, although it contains all of the factors desired, contains also factors irrelevant to the problem that cannot be dropped unless the formula is changed, which would cause confusion.

Measuring Particular-Function Efficiency

There is another use of this type of analysis which should be discussed. The fact that one can, for any set of conditions, determine the lowest cost-arrangement brings up the possibility of measuring the efficiency of the particular function. Taking a practical illustration, let us assume that a plant having the foregoing data is operating at two set-ups per year, having found from practical experience that two set-ups are better than one. The cost of doing this was $1,650, as shown by equation (5).

The cost involved with four set-ups, shown to be most economical, was $1,275, as shown in equation (14), the difference in cost being $1,650 − $1,275 = $375; or, expressed in percentage over the lowest cost, 29.4 per cent. This shows that the particular function is operating at a cost of 29.4 per cent too high. If only one set-up had been used, this would have been over 100 per cent; that is, ($2,850 − $1,275)/$1,275 = 124 per cent above the lowest cost-combination.

There may be some objection to basing efficiency, if this is to be computed, on the lowest cost-factor, since it is quite possible that a negative efficiency will result which is, of course, absurd. The procedure, however, does have two distinct advantages. First, the fact that the lowest cost obtainable is known avoids any illusions as to functional efficiency. Over any given period, costs can be reduced considerably; yet such a reduction may be insignificant as compared to the possible reduction. At any rate, it affords no measure of efficiency, the two costs being merely relative without an actual basis. Knowing the lowest cost obtainable does, however, give one a measure of how much the particular cost reduction did increase efficiency.

Second, since basic conditions vary from time to time, a variation in the cost of any one function cannot be a measure of how effectively or ineffectively the function is being handled. It may happen, for example, that one of the factors has been reduced to such an extent, because of changing business-conditions, that even what appears to be a large saving is not an increase in efficiency. On the other hand, the cost of a factor may have increased; hence, total costs are higher for this period than for the preceding one. Whether they are higher in proportion or not, however, cannot be determined unless the lowest cost obtainable, for that set of factors, is known. To illustrate this more clearly we will use a set of definite figures.

For the simple equation involving the two variables, let us assume as before the following data, for 1930; that is, N = 30,000 pieces, the production per year; C = $3, the cost per piece; I = 6 per cent per year, interest rate; and S = $150, the set-up cost. The plant was operating with two set-ups; hence, the cost as shown previously was $1,650. It was also shown that this

was \$375 more than the lowest cost-arrangement. But let us now assume that business conditions have changed for the year 1931 and that we then have new values for the factors C and I; namely, \$4 as the cost per piece and 9 per cent as the interest rate, the factors N and S retaining the same values as for 1930. Assume also that the plant continues its operations on two set-ups. Then we have

$$\text{Cost (2 set-ups)} = [2 \times 150\ (S)] + \left(\frac{[30{,}000\ (N) \times 4\ (C) \times 0.09\ (I)]}{2\ (A) \times 2\ \text{(set-ups)}}\right) \quad (16)$$
$$= \$300 + \$2{,}700$$
$$= \$3{,}000$$

The increase of 1931 costs over 1930 costs would then be \$3,000 − \$1,650 = \$1,350.

With the cost almost doubled, the question arises as to the justification of this increase. Technological efficiency has remained unchanged, wages are the same as in former years, output remained constant, and the set-up cost remained the same; so, there is no visible proof except that the material prices and the rate of interest increased. Unless the foregoing method is resorted to, there is no way of telling whether or not this increase in cost is justifiable and whether it is in proportion to the increase in the other factors or not. Let us measure this in terms of percentage. The new arrangement, according to the formula, should contain the following number of set-ups:

$$X = \sqrt{\left(\frac{[30{,}000\ (N) \times 4\ (C) \times 0.09\ (I)]}{2 \times 150\ (S)}\right)} \quad (17)$$

Therefore, $X = 6$ and the cost with this low cost-arrangement is

$$\text{Cost (6 lots)} = [6 \times 150\ (S)] + \left(\frac{[30{,}000\ (N) \times 4\ (C) \times 0.09\ (I)]}{2 \times 6\ \text{(set-ups)}}\right) \quad (18)$$
$$= \$900 + \$900$$
$$= \$1{,}800$$

The most efficient arrangement under the new set of conditions would involve a set-up every two months and a corresponding total cost of \$1,800. The net loss due to the arrangement for the two set-ups actually used is \$3,000 − \$1,800 = \$1,200. This compares with \$375 in 1930. If expressed as an arbitrary efficiency, the two figures compare as (1250/1650) = 76 per cent for 1930 and (1800/3000) = 60 per cent for 1931.

A similar combination could be worked out for other factors, increasing or decreasing any or all of them. The actual "lowest cost" will change, no doubt; but it will nevertheless remain the lowest cost obtainable under that set of conditions; that is, under conditions as they are.

This type of analysis can be used whenever capacity is greater than production, especially if the equipment can be used for other purposes than the one in question. It can be used to a very great advantage in purchasing when the time factor must balance with discounts or lower costs due to large quantities. It can be used in the shops in connection with the main product, drop forgings, castings, heat-treatment, and in all operations that are not continuous and involve a set-up. Even larger savings may be achieved by the application of this method to the relatively insignificant items, to supplies, tools and small parts, and to items which are bought in quantities with an almost entire disregard as to capital tie-up because the amounts involved are relatively small. The formulas will be different but the method will be the same; that is, to balance forces working in opposite directions.

THE DISCUSSION

CHAIRMAN JOHN YOUNGER[2]:—Mr. Lehoczky has taken a distinct step forward in developing formulas that include the lowest cost and the savings. In bringing forward the savings that can be effected, we will realize what we are accomplishing. Many old-timers cling to the idea of having just one set-up, and that this is the most economical set-up. Until this mathematical study was made, we had no idea that such savings could be effected.

A. R. FORS[3]:—In most of the automobile and accessories plants we have had only one problem to consider; that is, to obtain the lowest direct-labor cost on the quantities to be produced. The quantities were run continuously or in one lot. As conditions are today, we are faced with the problem of economical lot-sizes.

For a number of years I have been connected with the production division as production engineer. Recently, my work was changed to estimating and planning. This work has brought forcefully to my attention the necessity for analyzing our costs as affected by lot sizes. Not only is this true in production; it is true also in other departments, such as in the purchasing department.

We recently ordered 3000 units of a certain kind. Our purchasing department brought to my attention the fact that if we could order these units in 10,000 lots our costs would be reduced 20 per cent. The 3000 constituted our 30-day requirements, which is our usual basis for ordering material. However, as the 10,000 is approximately our 90-day requirements, this quantity was released, as the 20-per cent saving would more than cover the carrying charges. Mr. Lehoczky has brought out a number of points that will give us something to consider. I am sure we will change our viewpoint, which should result in considerable saving.


JOHN YOUNGER

K. W. STILLMAN[4]:—The practical application of economical lot-quantities has given more trouble than any other thing in connection with production. About ten years ago I was in charge of a ma-

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[3] M.S.A.E.—Production engineer, Continental Motor Corp., Detroit.

[4] Industrial Editor, *The Business Week*, McGraw-Hill Publishing Co., Inc., New York City.

terial-control department for a prominent electric company. That department had about 3000 separate items in its catalog and this required about 25,000 different items of material. We tried to establish an economical lot-quantity system of ordering material, and one can imagine what a job it came to be. Adequate control means, as Mr. Fors has said, that the formulas must be changed continually to meet the conditions, and it becomes a physical impossibility. We had more men in the department than we had out on the production floor.

ERIK OBERG

I tried to solve the problem at that time and succeeded very well by making a compromise formula, a comparatively simple one which did not include all the factors which might be considered but which did take into consideration what I thought were the important factors. From the formula I derived an alignment chart by which, after determining three or four important factors such as quantity of production, cost of set-up and cost of material, I could lay a straight edge on the large chart which was made up from the formula and could estimate an economic lot-quantity. Although not mathematically true absolutely, the result was much better than ordinary guessing, and this method worked fairly satisfactorily.

CHAIRMAN YOUNGER:—Since then, how much has that economical lot-quantity formula been put into practical use?

MR. STILLMAN:—I do not remember the formula. It was a very simple one with a maximum of five variables, the chief ones being the cost of set-up, the interest rate, the cost of materials, and the production rate.

CHAIRMAN YOUNGER:—Concerning economical lot-size formulas, in working for an engineering company recently I found that an increasingly large number of firms were paying attention to putting the lots of material through their plants in accordance with some kind of formula. They were not using hit-or-miss methods but really were trying to evolve some scientific method.

ERIK OBERG[5]:—The formula is an extremely important tool. It even can be applied to the publishing business to determine the economical number of copies of books to run in one printing. We sell an average number of copies each year, and we can calculate our book production by that formula, or a very similar one, quite accurately. Knowing the cost of printing, the cost of paper and so on, we can determine the economical number of copies of a book to be printed at one printing and stored away. So, this is a very universal formula and applies to almost all kinds of business. It should be considered very carefully.

J. GESCHELIN[6]:—Prof. F. E. Raymond, of the Massachusetts Institute of Technology, who has been one of the leading exponents of scientific methods, gives a new viewpoint on the problem in *Mechanical Engineering* for October, 1930. The paragraphs that interest me are as follows:

> Production at minimum cost is not economical. I mean by this that, in industries where intermittent processes predominate, it is possible to earn a larger annual return from the manufacturing operations on each dollar invested when the quantity of any product which is processed at one time is smaller than that for which the total unit cost of manufacture is a minimum, all other factors of the business having been fully considered. This situation is entirely due to the fact that the working capital of any concern of this type cannot be as effectively employed when manufacturing schedules are maintained upon a policy of minimum-cost production as they can when these same schedules are arranged so as to require the smallest average investment of capital and yet provide the greatest spread between the total unit-cost for a given scale of production and the prevailing price level.
>
> In studying this problem to determine the best lot-size, it was found that a greater rate of return could be earned upon the capital employed in the manufacture of a lot smaller than that which could be produced at a minimum cost, provided that it remained within a certain range below the minimum-cost quantity.

To me, this seems like a reversion to working without a formula, perhaps because it appears as if one can make more money by making as many pieces as are required at one time against an order.

PAUL N. LEHOCZKY:—The point is, I think, that Professor Raymond, who, incidentally, believes very much in this work, is driving home the fact. He has not explained this formula at all in this particular article. He is trying to drive home the fact that, while in truth it is cheaper to produce in quantity, that does not always represent the most economical production.

J. GESCHELIN

For example, the most economical production would be one set-up, running the Bullard Multaumatic 24 hr. per day, 365 days per year. That would be most economical. The other point is that, as we continue reading his article, he refers to one lot. One lot is the most economical, not considering the fact that one has material tied up, obsolescence and other factors to include. That is what I think he is considering. I believe he is not attacking economic lot-sizes. He is merely pointing out the fact that it is cheaper to produce more than one lot per year than it is to produce everything at one time during the year.

If one wants to set up a formula for any particular product, one does not need to change that formula unless some new factor enters, such as say another type of steel. If we have only the cost factors and only the quantity factors changing, we need not set up a new formula. In fact, after one formula is set up, we can

[5] M.S.A.E.—Editor, *Machinery*, The Industrial Press, New York City.

[6] M.S.A.E.—Associate engineering editor, *Automotive Industries*, Philadelphia, Pa.

compile a table and do not need to work from the formula later; we simply read the desired data from the table. That is the point I tried to bring out.

CHARLES D. OESTERLEIN[7]:—Does the formula include consideration of the changes brought about by seasonal activity?

MR. LEHOCZKY:—No; it was worked out rather simply to show the methods of reasoning and of attack as well as to enumerate the factors that work against each other and must be balanced. For seasonal production, the set-up is more elaborate. It may pay sometimes to force seasonality, or it may pay to shut down a plant for a long time. On the other hand, it may pay to run it straight through, depending upon the value of the production and other factors. It depends on the individual case.

The big thing in the formula is the averaging factor, which was one-half, as stated, because we assumed gradual sales-changing. As to what extent the factor is changing, this depends upon the shape of the seasonal curve; each would have a different shape and, depending on the shape, it can be analyzed rather simply. A larger or a smaller averaging factor would be used.

MR. OESTERLEIN:—How important, relatively, is the interest factor; that is the principal item to consider in a seasonal proposition?

MR. LEHOCZKY:—The interest factor includes not only interest on capital tied up, but also storage and handling costs that may accrue. Obsolescence works exactly the same as interest. On the other hand, the set-up charge and so on work on the other side. The interest factor is the most imporant in seasonal lines and, if the product is worth anything, I should say $10 or $12 per piece per unit, and where there are a large number of units, it represents the real saving. If it is worth anything as a comparative set-up cost, seasonal production will be used entirely. One will have more machines than in the case of continuous production, one will use them only part of the time and yet one will produce at a lower cost because of the savings in interest charges.

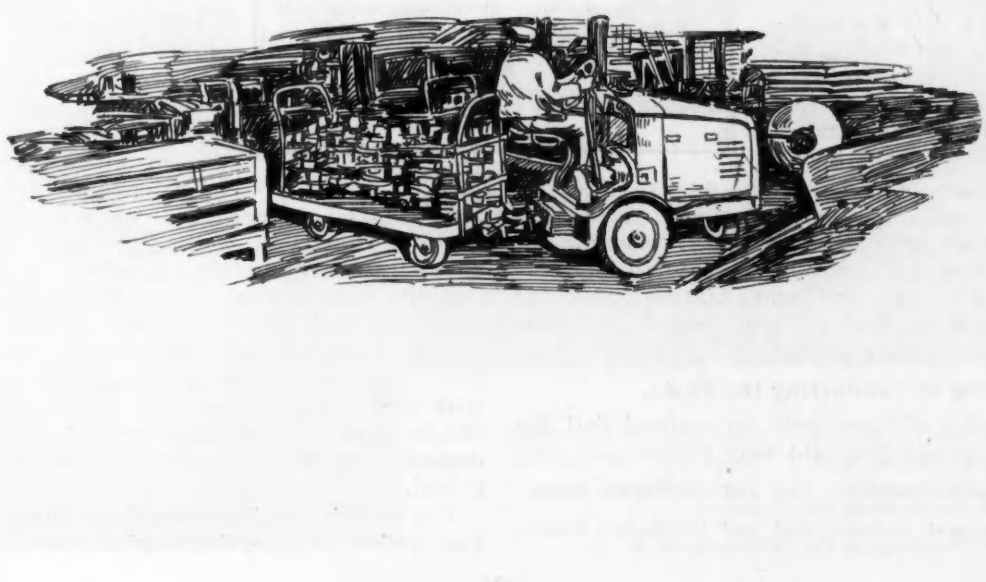
[7] Oesterlein Machine Co., Cincinnati, Ohio.

Aluminum Alloys Used in Commercial Vehicles

(Concluded from p. 217)

joints and attacked the aluminum. Such trouble can be overcome by the use of bituminous or rubber paints. There is nothing unusual, however, about such trouble, because we have had similar difficulties to overcome, regardless of the materials we used.

MR. GOLL:—In reply to Mr. Buchanan's remarks about the additional cost of aluminum bodies and Mr. Gresham's opinions on the same subject, my paper referred to the conventional type of aluminum commercial-bodies, while Mr. Gresham's statements apply to truck tanks. In the bodies to which I referred, the cost of manufacture is the same or less than for the steel body because, naturally, the material is lighter, easier to handle, and easier to form.



Cold-Starting Characteristics of Automobiles

By A. J. Blackwood[1] *and* N. H. Rickles[2]

MUCH HAS BEEN WRITTEN on the subject of cold starting by many able investigators, but it appears that the problem is still with us. It is our hope that the data presented in this paper will direct attention to some of the factors which may be easily controlled so as to give improved starting conditions.

Our laboratories have been able to attack this problem from a particularly advantageous angle through the cooperation of the Sales Department of the Standard Oil Co. of New Jersey, which has placed at our disposal all new cars purchased for their traveling personnel. This has made possible the accumulation of data which is uptodate in every respect and covers the latest models of several manufacturers in this Country. Every car included in the data presented is a 1930 or 1931 model purchased within the last 10 months and incorporates the most advanced design of the manufacturer relative to those features which affect the car's starting characteristics.

Cold starting of 14 new cars was studied in the laboratory at various temperatures and with oils of differing viscosity to find the cranking speeds at which the various cars would start and the temperature and oil-viscosity conditions under which such speeds could be secured.

Cranking speed was found to be the controlling factor, and some of the cars were found not to start at temperatures lower than 25 deg. fahr. with an oil having a viscosity higher than 18,000 Saybolt sec.

Volatility of the gasoline, while important, is not found to be a controlling factor. It is concluded a cranking speed of 35 r.p.m. is desirable on any car under the worst conditions anticipated.

Our tests were made with the car exactly as equipped by the manufacturer and all adjustments were made according to his recommendations. The tests themselves consisted in determining under what conditions we could: (*a*) secure a cranking speed to start the car and keep it running; (*b*) not start the car at all, due to too low cranking speed; and (*c*) develop various situations to bring out the different starting difficulties with a cold engine.

The two factors of fuel and lubricants were not separated, because of results obtained in previous tests in which we determined the effect of the lubricant upon the required starting torque, the shape of the speed-torque curves for various lubricants, and the relation of the electric-starter characteristics to the engine demands.

Method of Conducting the Tests

From the results of these tests we realized that the two factors of fuel and lubricant were inseparable, particularly since the starter itself established conditions unique for each individual car. For example, we often found that for a given set of conditions the engine fired on the first attempt to start it, kicked the starter out of gear and immediately stopped; and, no matter how many more attempts were made, the above cycle simply repeated itself. Yet, a matter of two or three higher revolutions per minute of the starter changed this condition completely. This in essence meant reducing the fluid friction of the lubricant sufficiently to permit more rapid rotation of the engine.

After the car was thoroughly run in, the crankcase was removed and cleaned, the carbon was scraped, the valves were ground, the ignition system was inspected, the spark-plug terminals and ignition-breaker points were set to the manufacturer's specifications, and the fuel system was thorously drained and blown out with air. Thermocouples were installed for determining the test temperatures. The crankcase was then charged with the oil to be used and the fuel tank charged with the test gasoline. Following this the car was placed on the chassis-dynamometer rolls in the low-temperature chamber, the general arrangement of which is shown in Fig. 1. This room takes the entire car, and its temperature can be controlled from −35 to +120 deg. fahr. The control apparatus, as well as most of the measuring and indicating instruments used, are located in the adjoining room, which is shown on Fig. 2. The engine was now warmed up until the oil temperature reached 100 deg., and the cooling water 160 deg. The car was then allowed to cool down overnight, usually to 0 deg. fahr. To expedite this cooling, the room temperature was held at −10 deg. until the crankcase-oil temperature reached 0 deg., when the room temperature was quickly raised to 0 deg., and the entire equipment then allowed to soak for 3 hr. This soaking period was found essential to obtain accurate and reliable data and cannot be dispensed with if reproducible results are to be obtained.

The actual starting operations were now conducted. The method of observing engine speed varied from car

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[2] M.S.A.E.—Mechanical engineer, fuel and lubrication laboratories, Standard Oil Development Co., Elizabeth, N. J.

to car; often considerable ingenuity was required to get the low cranking speeds accurately. Our most experienced man took his place at the wheel of the car with a stop-watch mounted in front of him, another stood alongside the car with a second watch to clock the time to the first explosion, while a third man checked the engine cranking speed. The foreman then stepped on the starter for 10 sec. with the ignition off. This was to determine the cranking speed in case the engine should start on the first attempt. The ignition was then turned on and the first starting attempt made, the starter being engaged for 10 sec. and then released if the starting attempt was unsuccessful. The throttle was set one-quarter open and the choke applied as skillfully as possible. A second attempt was made after 20 sec. had elapsed. This procedure was repeated up to nine times unless a start was obtained before that time. When a start was obtained, a record was kept of the time when it was necessary to close the choke and the time required before the engine would idle without the use of the choke. If the engine failed to start, the rear-wheel dynamometer was used to start it and the engine was again warmed up until the oil temperature was at 100 deg. and the cooling-water temperature was at 160 deg. fahr., after which it was cooled down to the next higher test temperature. All tests covered the use of at least two different lubricants in the crankcase and two or more gasolines in the fuel tank. To maintain accuracy, only two test temperatures per day were secured. Crankcases were always drained while hot and were flushed with the next test oil before recharging with that oil.

The question of storage-battery condition caused some concern, but it was finally decided to keep the battery outside the room during the overnight cooling and to recharge the battery after the attempts to start at each temperature. The battery was checked by the use of a hydrometer and by a stalling torque-stand test prior to each period of use. We have found that contact resistance at the battery terminals could produce a 25-per cent change in torque, and this alone probably accounts for many starting difficulties. This does not necessarily mean loose connections; as we have often checked the torque, then loosened the terminals, and upon retightening we have found the torque to be low. We now make special battery terminals for each test which are not disturbed from the battery while the car is on test. Irregularities in starting torques have virtually disappeared since taking this added precaution.

Data on Viscosity at Low Temperatures

When this work was begun it was found extremely difficult to secure accurate viscosity data at low temperatures to correlate results obtained. A very extensive program was therefore laid out, and viscosity characteristics of various oils were determined at temperatures from -40 to $+400$ deg. fahr., three viscometers being used. Fig. 3 is a chart giving the temperature-viscosity results obtained in the range covered by this paper. It is based on Vogel's equation, the three constants of which were obtained in the aforementioned work which covered tests on all the various types of crude. The construction of this chart is such that if viscosities at two temperatures of any oil are known, the viscosity at any other temperature falls on the straight line through these two points.

The determination of the constants and the development of the chart will be the subject of a later paper by R. G. Sloane and W. C. Winning, who developed it. At low temperatures the viscosities so determined are those for high rates of shear, and for this reason are applicable to the cold-starting conditions encountered in starting an automobile engine.

The method of determining the limiting conditions under which a car may be started is illustrated in Fig. 4. The data are plotted for two cars, one of which was easily started while the other may be classed as a hard starter. Each plotted point represents one test at a given temperature with a given lubricant in the crankcase. In every case, differences in cranking speed are

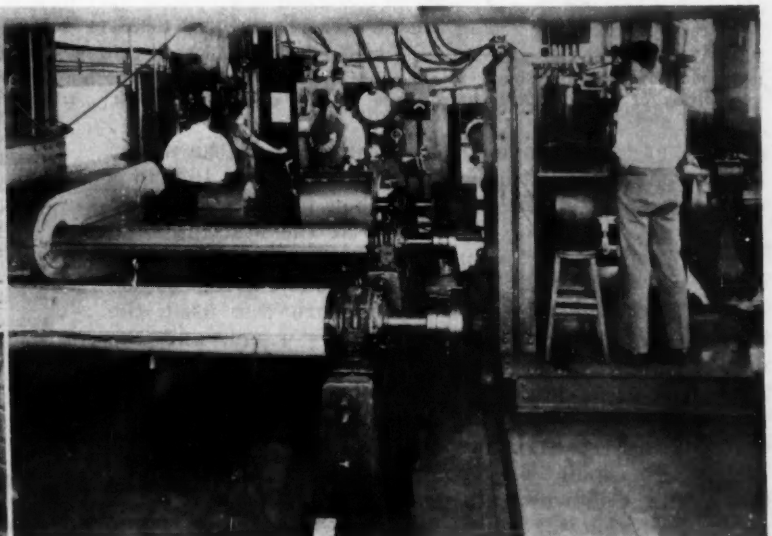


Fig. 1 (Left)—Low-Temperature Chamber of Standard Oil Development Co.

Fig. 2 — Control Apparatus and Instruments for Low-Temperature Chamber

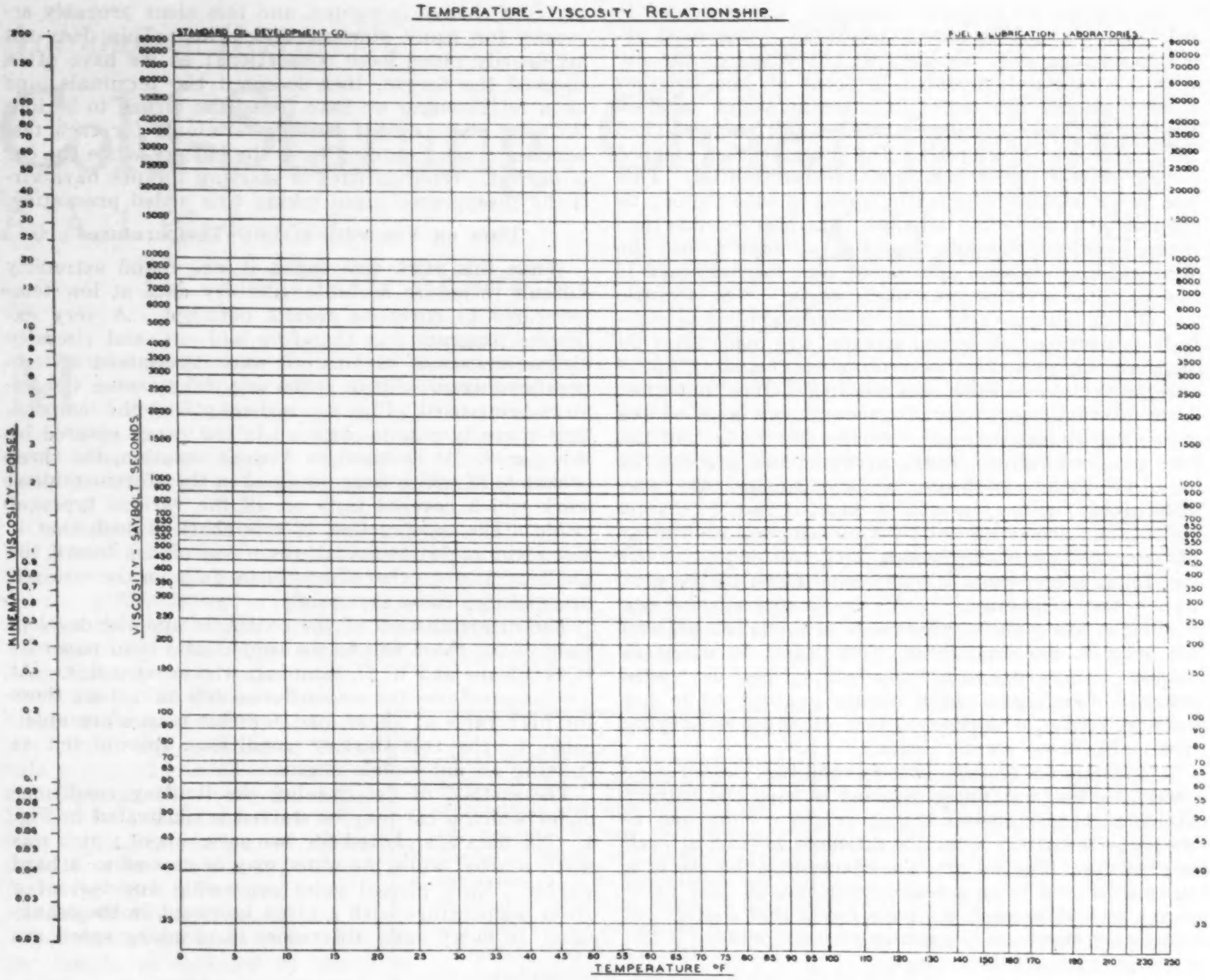


FIG. 3—TEMPERATURE-VISCOSITY RELATIONSHIP OF ENGINE OILS

The Viscosity of an Oil at Any Temperature Can Be Determined from This Chart by the Following Procedure: The Viscosities of the Oil Are Determined at 100 and at 210 Deg. Fahr., or at Any Two Temperatures, and Plotted on the Chart, and the Viscosity of the Oil at Any Temperature Can Be Read from a Straight Line Drawn Through These Two Points

due either to a change in temperature or to the use of a different lubricant. For example, car No. 16 had a cranking speed of 21½ r.p.m. when using a lubricant having a viscosity of 50,000 sec. at the starting temperature of 10 deg. fahr. Under these conditions a start was obtained. When a lubricant having 60,000 sec. viscosity at the same temperature was used, the cranking speed was reduced to 16½ r.p.m. and the engine did not start. The exact viscosity and cranking speed which would just produce a start is determined by plotting the data for all the tests made on each car and locating the limiting point on the curve. For car No. 16, this point lies between the conditions given above, and is shown on the chart at 19 r.p.m. and 55,000 sec. viscosity.

Sometimes the exact location of the starting locus is not so easily determined, particularly for cars that are hard to start. Car No. 1 illustrates this point. The car could not be started when the oil used had a viscosity of 17,000 sec., which permitted a cranking speed of 34 r.p.m., but the engine was started when the viscosity of the oil permitted a cranking speed of 45 r.p.m. The

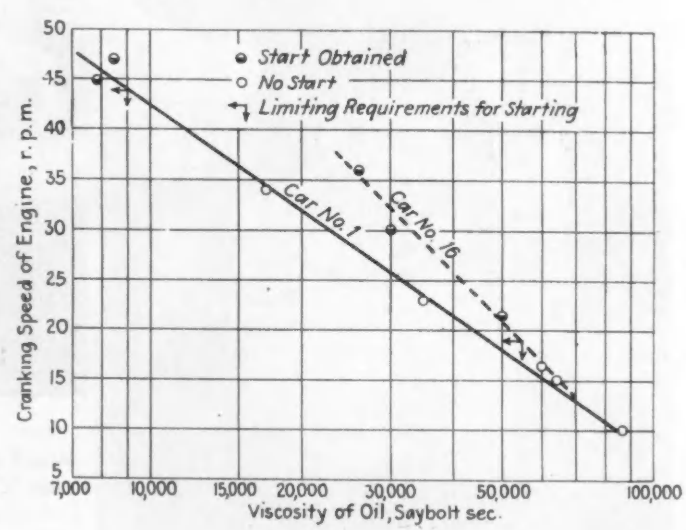


FIG. 4—LOW-TEMPERATURE STARTING TESTS OF TWO CARS

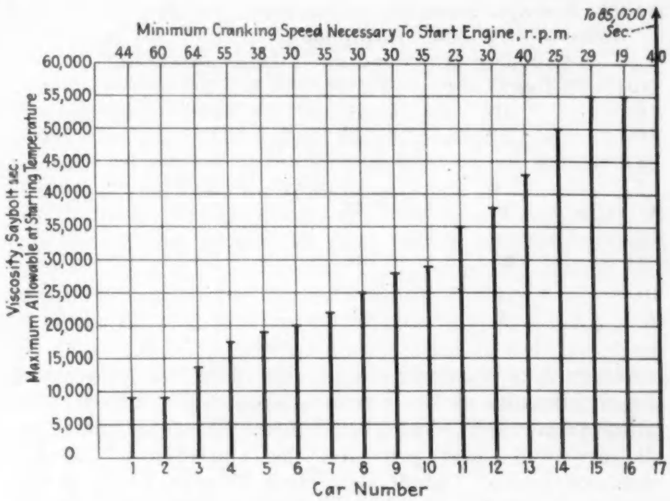


FIG. 5—LOW-TEMPERATURE STARTING DATA FOR VARIOUS CARS

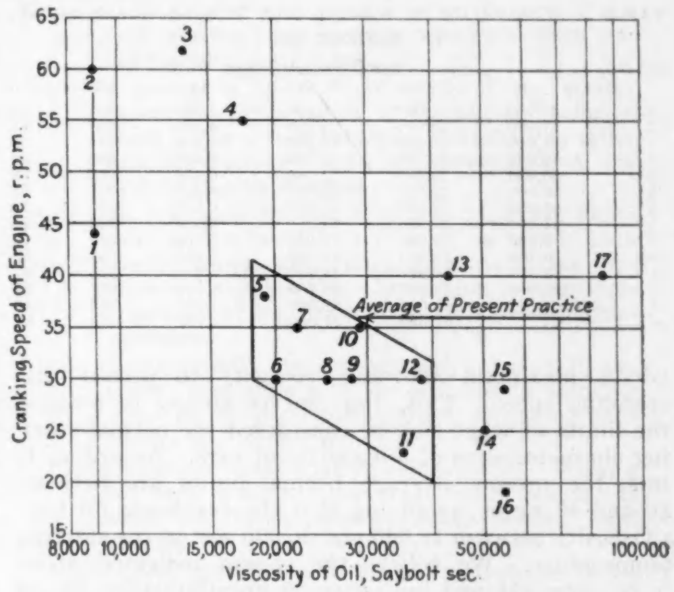


FIG. 6—MINIMUM CRANKING SPEED AND MAXIMUM VISCOSITY FOR EASY STARTING

The Points Are Designated by the Test-Car Number. Present Normal Practice Is Represented by the Group Enclosed in the Parallelogram

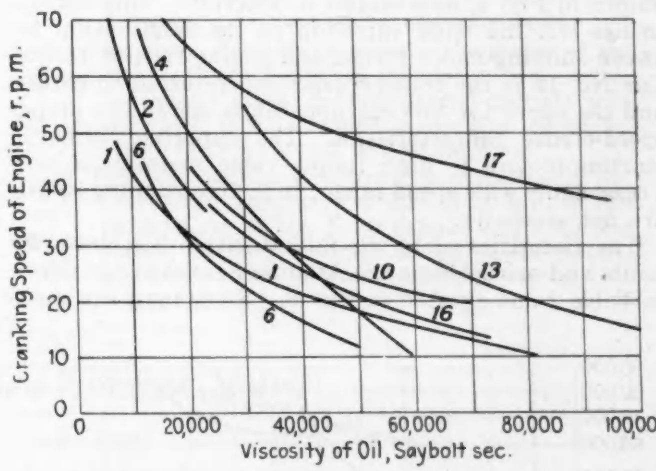


FIG. 7—CRANKING CHARACTERISTICS OF SEVERAL OF THE CARS TESTED

starting locus apparently lies between these two points. The exact location decided upon, 44 r.p.m. at 9000 sec. viscosity, was determined from the number of attempts necessary to get the car started at 45 r.p.m., the number of times the engine fired at 34 r.p.m. without starting, and the ease with which the engine was kept going after it had started. Fortunately such interpolation was not necessary in many cases. It will be observed that this chart, as plotted on semi-log paper, has straight-line curves. In other words, the viscosities as determined from the temperature-viscosity chart are applicable to engine conditions, and vice versa, the viscosity of the oil in the engine causing shearing resistances proportional to the viscosities determined at high rates of shear.

Cars Require Oils of Low Viscosity

Data for 17 different cars were collected in the manner described, and the results are given in Table 1 and

TABLE 1—LOW-TEMPERATURE STARTING DATA FOR CARS TESTED

Number of Cylinders	Car No.	Minimum Cranking Speed, R. P. M.	Maximum Allowable Viscosity, Saybolt Sec.
Cylinder Displacement Over 350 Cu. In.			
6	5	38	19,000
6	4	55	17,500
Cylinder Displacement from 300 to 350 Cu. In.			
8	1	44	9,000
8	9	30	28,000
8	10	35	29,000
6	14	25	50,000
Cylinder Displacement from 250 to 300 Cu. In.			
6	7	35	22,000
8	12	30	38,000
8	8	30	25,000
8	16	19	55,000
Cylinder Displacement Less than 250 Cu. In.			
6	2	60	9,000
6	6	30	20,000
6	11	23	35,000
6	13	40	43,000
6	15	29	55,000
4	17	40	85,000
6	3	64	13,500

shown graphically in Fig. 5. It will be observed that no relation exists between size of engine or number of cylinders on the one hand and ease of starting on the other. The striking thing about these data is the extremely wide variation from car to car. Two cars required that the crankcase-oil viscosity should not exceed 9000 sec. if starting is to be accomplished, while two others start readily with viscosities as high as 55,000 sec. The other cars are spread out evenly between these two extremes, with the exception of one four-cylinder car, No. 17, which started with an oil having a viscosity of 85,000 sec. at the starting temperature and had a cranking speed of 40 r.p.m. at the same time. If all cars could match the cold-starting performance of this model, there would not be much of a cold-starting problem.

Fig. 6 shows the data for all 17 cars plotted on a basis of minimum cranking speed necessary to start

TABLE 2—VISCOSITIES OF VARIOUS OILS IN S.A.E. CLASS NO. 20, SAYBOLT SEC.

Oil No.	Temperature, Deg. Fahr. 0	10	20	30	100	210
1	35,000	17,000	8,500	4,700	301	54
2	37,000	18,000	9,200	4,900	294	52
3	44,000	20,500	10,500	5,300	344	56
4	46,000	20,500	10,500	5,400	296	50
5	50,000	23,000	11,500	6,100	366	56
6	50,500	23,000	12,000	6,150	375	58
7	62,500	27,500	13,200	6,600	335	50
8	63,000	27,000	12,500	7,000	332	50
9	65,000	28,000	13,000	6,950	351	52
10	70,500	30,600	14,600	7,490	359	52
11	83,000	34,000	16,000	7,850	325	47
12	83,500	35,900	15,700	8,490	357	49
13	.....	45,000	21,000	10,000	388	49
14	.....	61,000	27,000	13,700	459	52

TABLE 3—DATA SHOWING IMPORTANCE OF CRANKING SPEED

Car No.	Temperature, Deg. Fahr.	Cranking Speed, R.P.M.	Attempts to Start	Start
16	10	15	9	None
16	10	30	1	Easy
11	0	15	9	None
11	0	43	2	Easy
11	10	33	9	None
2	20	50	9	None
2	30	68	1	Easy
10	0	19	9	None
10	0	38	4	Difficult

versus maximum allowable viscosity to permit that cranking speed. This chart serves simply to indicate the limits of what may be considered the normal starting characteristics of a majority of cars. According to this, the present average normal limits are between 20 and 40 r.p.m., requiring that the crankcase oil have a viscosity between 18,000 and 40,000 sec. at the starting temperature. We believe the spread indicated above to be excessive and indicative of unsatisfactory design on many cars.

Cranking Speeds Are Low in the Cold

Cranking speed of the various cars for different viscosities of lubricating oil at various temperatures is shown in Fig. 7, as a matter of interest. This further brings out the wide variation in the relationship between starting-motor torque and engine-friction torque. Car No. 17 is the four-cylinder one referred to before, and the curve for this car apparently shows the proper speed-torque characteristics. The important thing in starting-motors is high torque value maintained over a reasonably wide speed range; high free-running speeds are not necessary.

The viscosities of 14 oils falling within S.A.E. No. 20 limits and marketed on the Atlantic Seaboard are shown in Table 2 and charted in Fig. 8. Since most car manufacturers recommend oils of this class for winter use, the significance of the limits as determined in the foregoing paragraph become apparent. If we assume that all cars will start provided the viscosity of the oil does not exceed 18,000 sec., then 25 deg. fahr. is the limiting temperature at which these cars can be started. All but two oils would permit a start at 20 deg., while two others would permit a start at 10 deg. If we assume, optimistically, that all cars will start if the oil viscosity never exceeds 40,000 sec., then 15 deg. is the limiting temperature. In this classification, two oils will allow starting at 10 deg. and two at 0 deg. Naturally there are cars which fall outside these limits, but in the main we believe the foregoing will hold true.

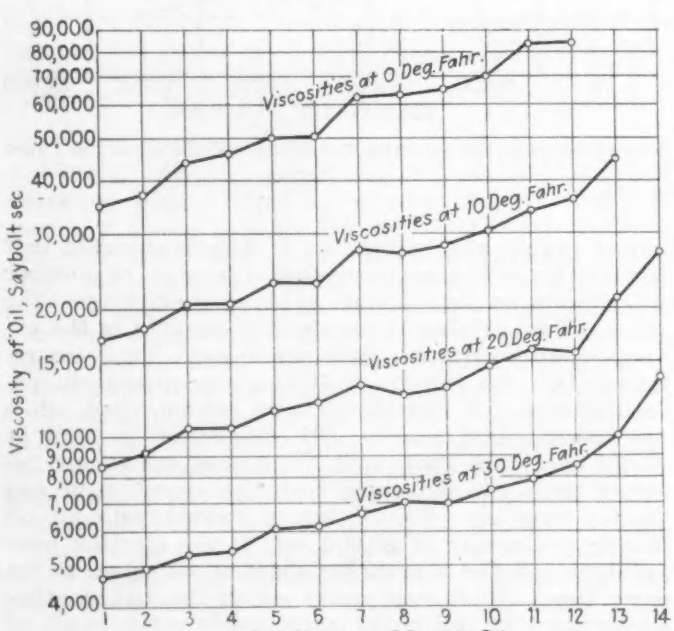


FIG. 8—VISCOSITIES OF VARIOUS SAMPLES OF OIL OF S.A.E. NO. 20 CLASSIFICATION

The results of these tests may seem inconsistent with the fact that people start their cars in subzero weather; but it must be remembered that all the tests reported were made with new oil in the crankcase, whereas under actual conditions the crankcase oil may have as much at 30 per cent dilution. Also, a car standing overnight in a sheltered place—particularly the battery, which is usually well insulated in its case—rarely gets down to the prevailing air temperature even after 8 to 12 hr. of exposure.

While there are undoubtedly differences in the ease of starting with gasolines having different distillation characteristics, our data lead us to the belief that this phase of the starting problem is receiving undue emphasis, and that the ultimate solution will be in: (*a*) designing the starting equipment, carbureters, manifold, and ignition systems so that starting at low cranking speeds will be possible; and (*b*) improving oils and changing oil specifications so that oils of suitable viscosity at the desired temperatures can be procured.

Cranking Speed Determines the Start

Some typical data emphasizing the importance of cranking speed are assembled in Table 3. We might summarize these data briefly as follows:

(1) Car No. 16, at 10 deg. fahr., fired seven times out of nine attempts with a cranking speed of 15 r.p.m. but could not be made to start. When the oil was changed to permit of 30 r.p.m. at the same temperature, the car was started at the first attempt.

(2) Car No. 11, at 0 deg., did not even fire in nine attempts when the cranking speed was 15 r.p.m. or below, but it started on the second attempt when an oil was used which allowed a cranking speed of 43 r.p.m. at the same temperature. When an oil was charged which allowed a cranking speed of 33 r.p.m. at a 10-deg. higher temperature, nine attempts to start failed although the engine fired on six of the nine attempts.

(3) Car No. 2 failed to start at 20 deg. with a cranking speed of 50 r.p.m., although at 30 deg. it started on the first attempt when the cranking speed was 68 r.p.m.

(4) Car No. 10, at 0 deg., failed to start at 19 r.p.m. and started with difficulty when an oil was used permitting 38 r.p.m.

Considering these four cars, one would not start at a temperature below 30 deg., while another started readily at 0 deg., showing that cranking speed and manifold design are the controlling factors.

These data must not be interpreted to mean that gasoline volatility has no significance in cold starting. Other factors being the same, it has an important influence; but the major factors are those affecting cranking speed, carburetion, and manifold performance under starting conditions.

Observations from Tests

A few of the experiences which we have had in testing various cars are enumerated in the following:

(1) Our earliest method of approximating cranking speed involved the use of a Neon tube held close to one of the spark-plug terminals and clocking the time for a given number of flashes. We subsequently found that in practically every instance a flash appeared every time any cylinder fired; in fact, if the spark-plug were removed from the engine and laid on its side, several weak sparks could be observed for every good spark. This did not happen at normal temperatures, and it is quite possible that moisture and reduction of insulating properties may add to starting difficulties in this manner.

(2) The heavy grease used to protect starter-gear splines during storage is not always removed when the car is assembled and in cold weather may cause the starter gear to remain in mesh and eventually ruin the starter armature by spinning it at too high speed. In the Bendix-type starter this prevents the gear from engaging with the flywheel.

(3) In general a 10-sec. application of the starter raises the temperature of the battery solution about 1 deg. It is therefore fallacious to think that the battery warms up appreciably on the first starter application.

(4) The frictional resistance of the crankcase lubricant at low temperatures may be higher than the full torque which the engine can deliver. We have had clutches slip when trying to turn some engines over by means of the rear-wheel dynamometer.

(5) The same fully charged battery, tested at 70 and 0 deg., may show a 50-per cent loss in cranking speed at the lower temperature, depending upon its age and condition.

(6) Carbureter floats stick in cold weather. When a car fails to start, it can occasionally be made to start very easily after striking the float bowl sharply.

Aside from the efforts which the petroleum industry is making to improve the low-temperature performance of its fuels and lubricaants, improvements along other lines are also necessary, and the following suggestions are offered:

(1) That car manufacturers and electric-starter manufacturers strive to produce a unit which will crank the engine at 35 r.p.m. or faster under the worst conditions which are anticipated.

(2) That some attention be given to the design of the choke to permit quick manipulation. In borderline cases a great deal may depend upon the skill and speed of the operator in handling the choke. Choke efficiency might well be improved.

(3) That the ignition-equipment manufacturers improve their apparatus so that good ignition can be obtained at low temperatures and very low speeds. Battery-terminal design should be improved to reduce contact-resistance losses.

An Internally Cooled Exhaust Valve

(*Concluded from page* 203)

dropped out of the race because of valve trouble. These were cars of which much was expected, but each of them had the misfortune to have a valve drawn into the cylinder. Compression-ratios in this race ranged from about 5.8:1 to 12:1. The winning car had a compression-ratio of 10:1 and second place was taken with a four-cylinder engine having a compression of 9.5:1.

One striking fact was that the first two cars to finish, averaging 100 m.p.h. for the 500 miles, showed gasoline consumptions of about 10 to 12 miles per gal. The race is having its effect on 1931 stock cars. I understand that one of them will have a compression ratio of 7:1.

The valves in a high-compression engine are subjected to extremely high temperature before they are opened, but the temperature is lower at the time of opening than in an engine having lower compression.

Improvement in spark-plugs also has played its part in making possible higher compression. The electrodes in the newest plugs project out of the shell so far that the inrushing gases keep them cool; but the insulator, inside the shell, gets red-hot, so that it will not get fouled when running even with a great deal of idling.

MR. HARRIS:—A night-flight test was made of a Wasp-powered Boeing mail airplane that was used in student instruction by the Boeing School of Aeronautics. The engine had been used for a total of 1411 hr., 100 hr. of which was since its last overhauling, at which time Friedl air-cooled exhaust valves and Venturi stacks were installed. The valves were made of Aerochrome non-magnetic metal, which is non-corrosive, and were not heat-treated.

The nine exhaust stacks had a total weight of 50½ lb., replacing an exhaust ring and stack weighing 107 lb. They produced a difference in pressure between the air-inlet tube and exhaust-pipe passage equivalent to 25 in. of water at full throttle at a cruising speed of 1625 r.p.m. and 30 in. of water at 2000 r.p.m. No flame was visible from this tube at full throttle with either a rich or lean mixture.

The engine speed at full throttle was increased from 1550 to 1660 r.p.m. on the ground and from 1850 to 2000 r.p.m. in the air. Noise was reduced about 15 per cent.

Production Engineering

Structural Welding Methods

Processes, Precautions and Results in Gas and Electric Welding Analyzed[1]

WELDED joints represent the maximum refinement in joining structural members, and they are readily adaptable to changes in design without expenses such as would be incurred in changing a riveted structure. Whether riveted or welded construction wins greater favor in the future will depend partly on the ease and economy of fabrication and the strength obtainable for a given weight of material. Heat-treating gives superior results in this respect.

Procedure control[2] has been developed by the American Bureau of Welding to increase the safety and reliability of welding. Those who are contemplating the use of welding or who have been welding without procedure control will find a study of this subject worth while.

Two major problems exist in connection with welding, the design of the joints and the responsibility of the welder to produce sound welds. Our attention here will be given to the production of sound welds. In this, the control of the gas-welding flame, electric-arc flame and the pressure and time of heating in resistance welding are of the utmost importance.

After the engineer in charge has decided upon the type of weld and the heat-treatment, the next task is to supervise and to keep a check upon the welding machine and operator. In the following I will consider the causes of failure and their remedy for welding operations of different types.

Oxy-acetylene, oxy-hydrogen, electric-arc and resistance-welding are used almost universally for aircraft and automobile construction in this Country. The tendency is to introduce automatic welding equipment to speed up production and reduce failures and costs. Automatic arc-welding machines for rear-axle housings and drive-shaft assemblies are being made by various manufacturers.

Zones of the Oxy-Acetylene Flame

The oxy-acetylene flame is the most widely-used method of welding. The neutral flame consists of three zones, as shown in Fig. 1, from an article by A. Rechlich and M. Schrenck[3]. The flame is reducing in reaction in zones 1 and 2. Zone 2, in which oxygen from the air is uesd in burning, is the best working portion of the flame. Infiltration of the air in zone 3 is more than is required for complete combustion, so that the reaction here is oxidizing and nitriding. The temperatures at different portions of the flame are indicated in Fig. 1. Decreasing the pressure on the oxygen in the flame results in a reducing reaction, in which free carbon is thrown out. Such a flame is lower in temperature than the neutral flame and has not such a clearly defined inner cone for zone 1.

Welding with a carbonizing or reducing flame increases the carbon content of the iron, thus making it less ductile in the affected area and more susceptible to fatigue failure than in a weld from the neutral flame. Reducing flames, in which the temperature is lowered by an excess of C_2H_2 as the free carbon escapes unburned, have been used successfully in welding heavy-gage aluminum. The excess of C_2H_2 also prevents oxidation, boiling and blowhole formation in the overlaid coating of hard-surfacing material in hard-surfacing tail-skid shoes.

Electric-Arc Welding

The components of the electric metallic arc as used for direct-current welding of low and medium-carbon steels are illustrated in Fig. 2. It will be seen that the electrode is negative and the work positive. The direction of the current is reversed for non-ferrous metals and for some steel alloys which are readily oxidized, because the positive side of the work is the hotter of the two.

With sufficient voltage to break down the air-gap through ionization, the arc forms part of an electrical circuit which generates sufficient heat to melt the rod and parent metals. As the metal of the electrode is melted into plastic globules, the globules proceed downward, under the influence of both electrical pressure and gravity, at the rate of 5 to 6 per sec. when the arc gap is of the correct length, usually 3/32 in. in light work. The arc consists of three parts: the central core, the intermediate stream and the outer flame. As the metal globules proceed to the crater, they short out the ark, carrying sufficient current to gain additional heat, and they are consolidated in the crater metal by capillary action. The current is maintained nearly constant by means of an arc-stabilizing unit in the welding-generator circuit.

The passage of less than five globules of metal per second indicates that the arc is too long, allowing contamination from atmospheric air which is usually expanded by the heat of the arc so that it causes an explosion as the metal particles impinge upon the air, resulting in spattering the hot metal as the arc erupts. Even without eruption, too great an air-gap causes blowholes in the weld matrix. Similar conditions result when the arc is advanced too rapidly, leaving a porous and coarsened top to the weld bead.

Another common cause of difficulty with the arc prevails when too much current is used or when the arc is advanced too slowly. Under these conditions, the excessive heat melts more metal than can be consolidated in the weld, and an unnecessarily thick bead piles up. The surplus metal flows over the side of the bead and is chilled so that it cannot be fused with the parent metal, leaving an overlap of useless metal. Under most of these conditions, the metal is badly burned and oxidized. Remedies lie in the use of current, arc length, size of rod and speed of welding that are correct as specified for the thickness of metal being welded.

Insufficient current results in an undersized bead and insufficient penetration of molten metal or depth of fusion to give a strength of weld equal to that of the plates being welded. A correct weld has good fusion, no blowholes or "cold shuts" and no overlap. Use of the correct size of rod, correct length of arc, suitable welding current, thoroughly trained operators and correct position and speed of the electrode are essential in the production of sound welds.

Resistance Welding

Resistance welding—including butt, flash, seam, upsetting, projection and spot welding—have been applied to both automobile and aircraft production by the Ford Motor Co. The principle utilized is that a poor conductor of electricity heats more rapidly than does a good conductor. Passing large flows of alternating current, 19,000 amp. average, through mating sheets or tubes which are clamped by elec-

[1] Abridged from paper read at a recent meeting of the Northern California Section by N. F. Ward, assistant professor of materials treatment, University of California, Berkeley, Calif.

[2] See S.A.E. JOURNAL, December, 1929, p. 677.

[3] See 1927 Jahrbuch der Deutschen Versuchsanstalt für Luftfahrt, p. 76. Translated in N.A.C.A. Technical Memorandum No. 453.

trodes causes the steel to be forged electrically at plastic heats or consolidated as one unit at the point where the heat is localized. Typical applications of this method are to wire wheels, automobile bodies, airplane struts, drive-shaft assemblies, rear-axle housings and frame reinforcements.

Temperature Stresses in Welds

Successful welding involves a close study of the chemical and physical effects of welding heats upon the metals at the weld and the parent metals. The effect of expansion and contraction is important in welding technique. Contraction or shrinkage during cooling localizes cooling stresses in the parts affected. If these stresses are not compensated for by annealing operations, fluxing rods and suitable width of gap between plates or structural members, failures occur where the internal stress is greatest when the parts are subjected to external loads.

If the welding is done at a temperature of 3000 deg. fahr. while the metal in the original plate is heated to only 1000 deg., the weld will shrink three times as much as the original plate. The metal at the juncture must yield sufficiently to take up the difference in contraction. Failure is prevented by superior strength and ductility of the steels being welded in many cases where no elaborate methods are followed to adjust or distribute the temperature stresses.

Preheating of the casting before welding and gradual cooling after welding is essential to success in welding cast iron, since this metal has virtually no ductility and the slightest amount of localized temperature stress will cause inherent cracks in the iron matrix and hasten failure at these points.

Annealing Needed to Preserve Strength

Welding processes in general leave the weld and its adjoining parts with less actual strength than would be indicated by the natural strength due to the chemical composition and grain size less the temperature stresses. Temperature stresses are higher or more intensified when the areas in which the heat is localized are small. As the heated area is reduced because of high welding temperatures, the stress intensity approaches or exceeds the safe working stress of the material if no adjustment of stress has been provided for by annealing, peening or fluxing rods. Evidences of excessive temperature stresses are found in surface cracks in and near the welds. The strength of a weld is maximum only when the temperature stresses are reduced to the minimum.

Annealing may be of two kinds: (*a*) stress-relief annealing, accomplished by heating the weld and adjacent areas to a dull red heat and allowing them to cool in the air; (*b*) full annealing, done by heating the welded material above the critical temperature long enough for recrystallization of the grain structure to smaller size and permitting the metal to cool to room temperature in the air. Peening is done after the weld is completed and has a similar result to hot-working of the metal, which refines the iron grain and distributes the temperature stresses. Fluxing rods are used to prevent chilling of the weld while it is cooling and serve to prevent contamination of the weld with air. All of these methods are intended to increase the strength of the weld through increasing grain strength and decreasing the severity of the temperature stresses.

Temperatures for Resistance Welding

Resistance-welding temperatures are in the forging range, about 2200 deg. fahr. Stresses are localized closer to the bonding surface than in other types of welding because the heat is concentrated more intensely under the electrode surfaces, resulting in the development of a coarse grain structure in this region. A study of failures in resistance welding show more abrupt changes from coarse to fine grain structure than in gas or arc welding. Failures of resistance welds in this area are common. For illustration, a spot weld in hot-rolled steel plate failed by separating at the juncture between the coarse and fine grain, the coarsened-grain portion pulling out as a rivet is pulled from its hole. Full annealing must be resorted to in order to improve the grain strength after this weld.

Difficulties in producing welds of optimum strength increase as the speed of welding increases in automobile and aircraft manufacture. Many difficulties have yet to be overcome in welding, but modern science has assisted in making the method effective for joining structural members. The economic question is not how fast a weld can be made so much as it is how much it will cost to make a weld stronger and more serviceable than a joining made by other methods of fabrication.

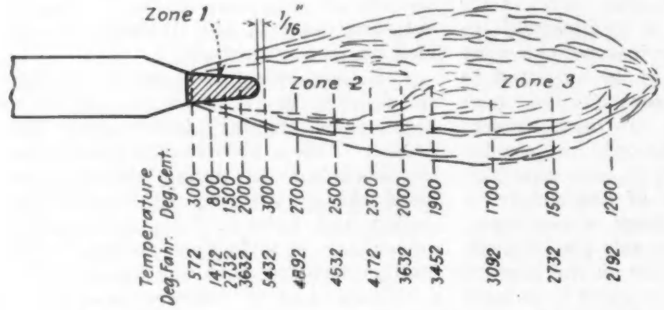


FIG. 1—NORMAL OXY-ACETYLENE WELDING FLAME

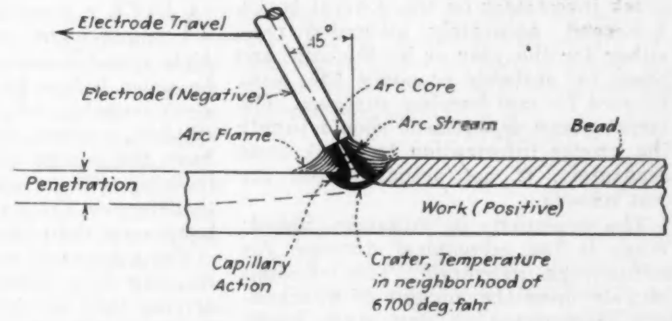


FIG. 2—DIAGRAM OF WELDING PROCESS WITH METALLIC ARC

Transportation Engineering

Important Distinction Made

Cost Finding and Keeping Versus "Cost Accounting" Analyzed by A. J. Scaife[1]

THIS question leads to a point that is frequently overlooked; namely, the difference between general accounting and cost-keeping. Much of the difficulty with depreciation would be eliminated if the truck owner would distinguish between the depreciation that he prefers to set up for general accounting and tax purposes, and the depreciation that represents cost and expense figures. For the general accounts, an owner may set up some arbitrary method that will write the truck off the books somewhat before the truck actually becomes of no capital value. Some might want to write the equipment off as fast as possible; but the owner should not assume that this amount of depreciation is true operating cost.

To obtain accurate costs, however, the owner must bring his own experience factor into the situation. He must recognize the variable life in different makes and the underlying variable conditions, and approximate greater or smaller economic life in his method of depreciation. Sometimes he will find it necessary to re-estimate his operating charge for depreciation, because the original estimate of economic life was not correctly made. Where an arbitrary annual rate of depreciation is to be used for the reduction of truck investment on the general books, a second, accurately estimated rate, either for the year or by the mile and based on probably economic life, must be used for cost-keeping purposes. The maintenance department should supply the proper information to check costs accurately, if not actually keep the cost records.

The question is ofttimes asked: What is the economical distance for motor-truck delivery? This depends entirely upon the amount of merchandise transported on any given route. To illustrate, a survey was made recently of a company delivering ice cream. The delivery system was divided into eleven routes running from 32 to 110 miles per day. The 32-mile route delivered 4411 gal. of ice cream per month; whereas the 110-mile route only delivered 760 gal. of ice cream per month. The short-mileage route called for 58 stops in one day, whereas the long-mileage route was scheduled for only 20 stops per day. The cost of delivery was 24 cents per gal. for the short route, and 76 cents per gal. for the long route, or over three times the cost per gallon.

In summing up the entire cost of delivery for the entire group, the average cost of delivery in 10 of the 11 routes was 35 cents per gal. and the one route is 76 cents per gal., which is well over double the cost of the average of the other 10 routes considered. Hence, one of several things had to be done; discontinue the route, increase the business, or arrange to ship the merchandise by express provided the rate is low enough.

By keeping accurate cost-records, it is very easy to determine just which the profitable routes are and so avoid conditions similar to those already mentioned; because it is possible to use cost records from each one of different routes and thereby determine the delivery expense. This, together with the potential volume of the merchandise possible to sell on each route, will enable one to determine the economical distance for motor-truck delivery.

The greatest problem in this Country today is the problem of distribution. Economists admit that, as an average, it now costs more to distribute than it does to produce. We are living in a mechanical age in which quantity machine-production has pared to the bone production costs. If there is to be any further material reduction of living costs in this country, it must lie in the reduction of the distribution part of the cost of merchandise and products. Produce is transported over the highways from the farm, the forest, the mine and the factory, from wholesale to retail stores and from store to consumer four, five and even ten times to the once or twice it is shipped by rail or water. Here is the part of the cost that must be reduced. The motor truck is the development of this century for the job. Why hamper it? Use it.

[1] M.S.A.E.—Consulting field engineer, The White Motor Co., Cleveland.

Three Driver-Training Methods

National Safety Council Pamphlet D-3 Classifies Kind of Instruction Needed

AFTER a man has been selected for employment as a commercial-vehicle operator, certain instructions must be given before he can be expected to work capably. In general, the most efficient, prompt, and courteous drivers have the fewest collisions, but proper training will do much to overcome any tendency on the part of any driver to have more than his share of accidents.

The amount of emphasis placed upon training drivers depends on the kind of driving they will be required to do and the resources of the organization for giving instruction. Replies to a questionnaire, sent to members of the National Safety Council who operate motor-vehicle fleets, indicate clearly three distinct methods of instruction, each applicable under certain conditions:

(1) City bus companies usually prefer men—when they may be had—who have never driven, so that they may train their drivers from the beginning in the correct method of operating motor-vehicles. Thus, old and often faulty habits of driving do not have to be broken down and replaced by new ones which have been definitely demonstrated as safe and efficient. A considerable part of this training is carried on in a classroom.

(2) Companies who employ helpers for drivers almost invariably prefer to have each regular driver train his helper. This apprenticeship system has the advantage of giving the management the opportunity to observe the ability and habits of the prospective driver for a long time before he is finally intrusted with the operation of a vehicle, and it becomes possible to use the more experienced helpers as drivers during the busy season. Firms engaged in package delivery, motor freight, moving and storing, baggage transfer, trucking of building materials, and sometimes in handling coal and ice, usually follow this method.

(3) A miscellaneous group of employers selects men who have previously learned to drive, and instructs them only in the non-driving details of their particular business. Firms in the taxicab, milk, bakery, ice, and laundry businesses, and those which furnish salesmen, repairmen, inspectors and collectors with automobiles, generally follow this method.

Reports of Society Committees

Meetings Committee Report

THE 11 National meetings staged by the Society in the 1930 administrative year, under the general direction of the Meetings Committee, were representative of the varied interests of the Society members, as all eight of the Professional Activities of the Society participated in arranging technical programs for these meetings. Five of the National meetings were on aeronautic topics, and the programs for these meetings, as well as certain sessions at the Annual and Semi-Annual meetings, were outlined by the Aircraft and Aircraft-Engine Activities. The Production Meeting was, of course, arranged by the Production Activity, and the Transportation Meeting was under the direction of the Transportation and Operation Activity and the Motorcoach and Motor-Truck Activity. The Annual and Semi-Annual meetings were cooperatively planned, all of the Professional Activities contributing to the success of the program in each case. The Passenger Car, the Passenger-Car-Body and the Diesel-Engine Activities, although holding no meeting devoted exclusively to their respective topics, made their influence felt by the contributions that they made to the programs of the Annual and Semi-Annual meetings. In addition to the meetings sponsored by the Professional Activities, the Society held, as usual, its Annual Dinner during Automobile Show Week in New York City, the arrangements for this interesting event being under the direction of the Annual Dinner Committee. Moreover, the Motorboat Meeting was held cooperatively with the National Association of Engine & Boat Manufacturers, and its program was arranged chiefly by the Papers Committee of the Metropolitan Section.

Several different parts of the Country entertained the National meetings of the Society in 1930, as the 11 meetings held throughout the year were staged in 7 different places. Detroit was the site of three of the meetings, and New York City was host to an equal number. The five other meetings were held respectively in French Lick Springs, Ind.; St. Louis, Chicago, Pittsburgh, and Miami, Fla., as will be seen from the accompanying table which presents several facts of interest in connection with the National meetings held during the 1930 administrative year.

The Society has cooperated with other organizations in the holding of several of the meetings mentioned above. For example, the Aeronautic Meetings have been held in cooperation with the Aeronautical Chamber of Commerce of America, the Miami Aeronautic Dinner being held also in cooperation with the Greater Miami Industrial Association. The Motorboat Meeting, as already noted, was held in cooperation with the National Association of Engine & Boat Manufacturers.

Section hospitality has been offered to the National Society whenever a meeting has been held in a city containing a local Section of the Society. The Detroit, St. Louis, Metropolitan, Chicago and Pittsburgh Sections have done the honors for National meetings during the administrative year just completed, and much of the success of the meetings is directly attributable to the earnest and well-directed efforts of the Section officers and members.

A noteworthy feature of the work of the Meetings Committee in the last year was the staging of the 25th Anniversary Celebration and Pageant in connection with the Summer Meeting at French Lick Springs, Ind., in May. Exhibits in the Exposition Hall were available for inspection throughout the meeting and the pageant on the third day of the meeting was a spectacle that gave pleasure to the many hundreds of people who witnessed it.

The 1930 Meetings Committee has consistently emphasized the desirability of starting all technical sessions on time, the necessity for adhering to a definite and predetermined schedule in the presentation of papers, and the greater effectiveness obtained by refusing to overcrowd any session by the inclusion of so many papers that time will not be available for discussion.

NORMAN G. SHIDLE,
Chairman.

NATIONAL MEETINGS HELD FEBRUARY, 1930, TO JANUARY, 1931

Meeting	Location	Date	No. of Sessions	No. of Papers
	1930			
Aeronautic	St. Louis	Feb. 18 to 20	6	12
Aeronautic	Detroit	April 8 to 10	4	6
Aeronautic	New York City	May 6 and 7	5	9
Semi-Annual	French Lick Springs, Ind.	May 25 to 29	13	26
Aeronautic	Chicago	Aug. 26 to 28	6	10
Production	Detroit	Oct. 7 and 8	4	8
Transportation	Pittsburgh	Oct. 22 to 24	6	11
	1931			
Aeronautic	Miami, Fla.	Jan. 8	1	2
Annual Dinner	New York City	Jan. 8	1	1
Motorboat	New York City	Jan. 22	1	3
Annual	Detroit	Jan. 19 to 23	17	34

Membership Committee Report

THE Committee presents the following membership statistics for the last year and also comparative figures for 1929 to show the progress made during the year.

MEMBERSHIP BY GRADES FOR THE YEAR ENDED DEC. 31

	1930	1929
Members	3,564	3,394
Foreign Members	262	210
Service Members	101	87
Associates	2,286	2,237
Juniors	700	647
Affiliates	116	112
	7,029	6,687
Affiliate Representatives	170	181
Students	300	355
Grand Total	7,499	7,223
Applications for Membership Received	955	1,214
Percentage of Applicants Qualifying	77	68

The total net gain in members for the year was not as great as those of the last few years but the Committee feels that this is entirely justifiable due to recent business conditions, and at this time it wishes to express its sincere appreciation to those who have assisted in the work and made such a growth possible.

F. K. GLYNN,
Chairman.

Publication Committee Report

THE year ended Oct. 31, 1930, showed continued increased publication activity of the Society. In accordance with the authorization of the Council at the Semi-Annual Meeting in 1929, more text pages of papers and discussion were added to the monthly issues of the S.A.E. JOURNAL, the increase amounting to 462 pp. in the fiscal year and to 122 pp. in the calendar year ended Dec. 31, 1930, compared with corresponding periods one year previously. Revenue advertising showed an increase of 16¼ pp., from 1420 to 1436¼, in the fiscal year, and a decrease of 148¾ in the calendar year. The ratio of text pages to advertising pages showed an increase, while the

S.A.E. JOURNAL

	Fiscal Year, Oct. 1 to Sept. 30			
	1928-1929	Per Cent	1929-1930	Per Cent
Text Pages	1,415½	49.9	1,877¼	57
Revenue Advertising, pp.	1,420	50.1	1,436¼	43
Total Papers and Discussion, pp.	789	55	1,113½	59
Total Departmental Matter and News, pp.	635¾	45	763¾	41
	Calendar Year, Jan. 1 to Dec. 31			
	1929		1930	
Text Pages	1,715¼	54	1,837¼	58
Revenue Advertising, pp.	1,470¼	46	1,321½	42
Total Papers and Discussion, pp.	875	58	1,074½	58
Total Departmental Matter and News, pp.	620	42	763¾	42

ratio of text pages of papers and discussion to departmental matters and news pages increased slightly in the fiscal year but remained the same for the calendar years 1929 and 1930.

The accompanying tabulation presents the data for easy comparison. The Council, at its meeting in December, authorized continuation on the present basis of text pages, notwithstanding the decrease in revenue advertising, feeling that the business situation will soon improve and that the prestige of the S.A.E. JOURNAL should not be allowed to suffer.

During the last year many improvements have been made in the typography and general appearance of THE JOURNAL.

Transactions

TRANSACTIONS for 1929 was published and mailed in June, 1930, one month earlier than in 1929. The book was printed in a single volume and in one part, whereas in 1929 it was printed in two parts in one volume. Last year 3250 copies were distributed to members without charge, compared with 1628 copies in 1929. The volume for 1929 contained 700 pp., compared with 580 pp. in TRANSACTIONS for 1928, and 19 more papers with discussion were printed last year than the year before. The figures are tabulated herewith.

TRANSACTIONS

	1928 (Two Parts)	1929 (One Part)
Pages	580	700
Papers and Discussion	72	91
Classifications of Papers		
Passenger-Car Research and Design	5	7
Engines, Fuels, Lubricants and Superchargers	32	34
Chassis Parts	4	7
Production	11	4
Aircraft	8	20
Motor-Truck, Motorcoach and Rail-Car	4	6
Operation and Maintenance	6	13
Materials	2	..
Copies Distributed	1,628	3,250

Handbook and Roster

The 1930 S.A.E. HANDBOOK of Standards also showed an increase, of 48 pp., with a slight decrease in revenue advertising. Five more pages were contained in the List of Advertisers of Products Conforming to S.A.E. Standards in the 1930 HANDBOOK than in the 1929 HANDBOOK.

S.A.E. HANDBOOK

	1929	1930
Pages	680	728
Advertising Pages	43	35
List of Advertisers Conforming to S.A.E. Standards, pp.	45	50

The S.A.E. Membership Roster for 1930 was issued in a somewhat larger page size than formerly and contained 20 pp. less than in 1929 but listed 364 more members, including Affiliate Member Representatives and Enrolled Students. For the first time it contained a list of Enrolled Students and also a list of members deceased in the preceding year.

S.A.E. ROSTER

	1929	1930
Pages	442	422
Members Listed, Including Affiliate Member Representatives and Enrolled Students	6,854	7,218

JOHN YOUNGER,
Chairman.

Research Committee Report

THE research projects to which the Society's Research Committee has devoted attention in the last year are fuels, riding comfort, wheel alignment and motor-truck impact-tests.

A study of gasoline characteristics in relation to acceleration performance, vapor-locking tendency and detonation have occupied a goodly share of consideration in the research activities of 1930.

Engine Acceleration

At the S.A.E. 1930 Summer Meeting, C. S. Bruce presented a final report[1] terminating a study of the relation between economic fuel-volatility and engine acceleration, which has been the subject of periodic reports before the Society for the last few years.

Vapor Lock

The investigation of vapor lock in airplane fuel-systems, undertaken in 1929 by the Bureau of Standards under the direction of the Fuels Research Subcommittee with funds provided by the Naturaline Co. of America, revealed the problem as one equally pertinent to the automobile industry. To convert the technique and equipment developed in this phase of the study to the advantage of the automobile industry, the Cooperative Fuel Research Steering Committee elected to sponsor an extension of the project to the automobile field.

A concluding report on the airplane phase of this research was presented at the Summer Meeting in a paper by Dr. O. C. Bridgeman and H. S. White, entitled Effect of Airplane Fuel-Line Design on Vapor Lock[2]. At the same meeting a paper entitled Effect of Weathering on the Vapor-Locking Tendency of Gasolines[3] was presented by Dr. Bridgeman and E. W. Aldrich.

Since the Steering Committee felt that designers of automobile equipment could do much to minimize trouble from vapor lock by reduction of fuel-line temperatures, the decision was made to concentrate during the warm summer months on the phase of the program dealing with temperature measurements in automobile fuel-systems under operating conditions. The investigation was undertaken on a cooperative plan, and these tests have resulted in information concerning the design characteristics that influence vapor lock and have indicated the changes that the engine designer can effect to secure the best possible performance with the fuels available. These results are reported in detail in a paper entitled A Survey of Current Automobile and Motorcoach Fuel-Line Temperatures, by Dr. O. C. Bridgeman and H. S. White.

Detonation

During the last year rapid strides have been made in the work on the three essentials to a uniform method of measuring the antiknock qualities of fuels. These are: first, a standarized engine and accessories; second, a common reference-fuel or scale of fuels; and third, a uniform procedure.

The design and construction of the Horning engine and preliminary tests have been referred to in previous reports. These tests indicated certain necessary minor changes in the design of the engine. At a recent meeting announcement was made that all suggested changes had been incorporated

[1] See THE JOURNAL, September, 1930, p. 274.
[2] See THE JOURNAL, October, 1930, p. 444.
[3] See THE JOURNAL, September, 1930, p. 344.

in the engine. Certain accessories to the engine, such as a suitable carbureter, power-absorbing medium and other parts, are still in the course of development. The effect of engine variables on knock-testing results is the subject of a symposium sponsored by the Detonation Subcommittee scheduled to occupy an entire session at the forthcoming Annual Meeting.

Following the item of apparatus, the next essential to a uniform method of knock rating is a common scale of reference fuels. This second item has been settled upon by agreeing to use normal heptane and iso-octane (2, 2, 4-trimethyl pentane) as primary standards. The Lubricants Division of the S.A.E. Standards Committee now has before the Standards Committee a proposal that this be made an S.A.E. Recommended Practice.

The third essential to a uniform method of knock rating is a common procedure or method for making measurements. This phase of the work constitutes the present program.

Another noteworthy step toward the ultimate goal of the Detonation Subcommittee's work, that is, the establishment of a universally acceptable method of expressing knock-testing results, was taken when a group working along similar lines in Great Britain accepted the invitation of the Detonation Subcommittee to participate in this project. Negotiations are under way to extend this participation to other countries.

Diesel-Fuel Research

Profiting by the experience of the gasoline industry, which faced the problem of meeting gasoline specifications established prior to a fundamental knowledge of gasoline characteristics, a program of research on the basic characteristics of Diesel fuels has been adopted so that data may be made available on which to base specifications when the need arises. In arranging for the financing of the project, the Ways and Means Committee is making a special effort to secure a large number of small contributions to the fund so that it may be not only a cooperative undertaking, but one truly representative of both the Diesel engine and petroleum industries.

During the year this committee brought to a conclusion the original assignment and a final report, summarizing its findings and recommendations, is now being considered.

Highways and Riding-Comfort

The Highway Subcommittee has continued to represent the Society on the Cooperative Committee on Motor-Truck Impact-Tests, under whose auspices the Bureau of Public Roads has been conducting truck impact-tests. With the cooperation of the Bureau of Standards in the study of instrumentation problems, data obtained in previous tests were analyzed and reports published in the July and September, 1930, issues of *Public Roads*. A program of motorcoach impact-tests is now under way.

Under a plan for coordinating the various phases of riding-comfort research, the work of the Riding-Comfort Subcommittee has made noteworthy progress in the last year. The investigation of bodily changes brought about as a result of riding fatigue has been extended to a larger and more-diversified group of subjects, including taxicab drivers. The results of these tests are reported in a paper entitled Bodily Steadiness—an Index to Riding-Comfort[4], presented at the Summer Meeting by Dr. F. A. Moss, of George Washington University, under whose direction this phase of the work has been carried out. In the course of the work an improved type of portable wabblemeter has been developed, and the results obtained using this device have been prepared for presentation by Dr. Moss at the forthcoming Annual Meeting.

Prof. Ammon Swope and G. C. Brandenburg, of the department of psychology, Purdue University, presented a report entitled The Psychology of Riding-Qualities[5] at the Summer Meeting. This report covered the results of the survey of subjective reactions of a limited number of riders. Recent progress in experimental work with the steadiness-meter will be reported at the forthcoming Annual Meeting.

B. B. BACHMAN,
Chairman.

[4] See THE JOURNAL, June, 1930, p. 804.
[5] See THE JOURNAL, September, 1930, p. 355.

Sections Committee Report

WITH the beginning of the fiscal year, the new dues plan went into effect thereby making all members residing in specified Section territories members of those Sections automatically. The Section territories were laid out on county lines and approved by the Council with the understanding that members residing outside of any Section territories might specify with what Section they wish to be affiliated, it also being understood that while they would be considered as a member of the specified Section, said Section would receive no dues for these outside members.

At the 1931 Annual Meeting the six probationary Sections will submit statements of the work carried on since their inception and submit formal application to the Council for official recognition as regular Sections. These Sections with their organization dates are as follows:

St. Louis	August, 1928
Pittsburgh	April, 1929
Wichita	April, 1929
Oregon	December, 1929
Syracuse	December, 1929
Baltimore	January, 1930

The success of all of these Sections, particularly Pittsburgh, Baltimore and Oregon, has been very gratifying and it is felt that the worth of the Society has been considerably enhanced by all of the new Sections.

The Twin-City Section, which was promoted but never reached the stage of holding any meetings, was abandoned and the money appropriated by the Council returned to the Society because of a decided lack of interest and support among the few members in the territory.

At present members in Kansas City are attempting to promote a probationary Section and a meeting will be held some time before Feb. 1 to determine the extent of the support and interest. It is significant to note that the Resignations Committee has received a letter since the Kansas City Section was projected, requesting it to hold up a resignation in view of the possibilities of a Section in that territory, which is somewhat indicative of the value of Sections in holding members.

The Sections have been very active in the professional activities, particularly aeronautics, with Wichita taking the lead and devoting all of its meetings to aeronautics, owing to the fact that the membership is over 90 per cent aircraft and aircraft-engine men.

B. J. LEMON,
Chairman.

Standards Committee Report

FOR the 1930 administrative year 18 Divisions of the Standards Committee were appointed in place of the 20 Divisions that were appointed the previous year, the changes being the discontinuation of the Agricultural Power and Equipment Division for the time being, the consolidation of the Transmission Division with the Parts and Fittings Division and the Motorcoach Division with the Motor-Truck Division, and the organization of the Diesel-Engine Division. A large part of the work of the Divisions was carried on during the year by 41 Subdivisions.

The special committees on Standardization Policy, Methods of Expressing Limits and Tolerances and on Patents were continued, the first named being the only one to meet during the year as the activities of the American Standards Association, other societies and associations with which the Society cooperates and the general economic and commercial situations have developed a number of questions affecting the Society's work. At the time of preparing this report a meeting of the Committee was scheduled to be held early in January to discuss policies in meeting the problems in standardization.

Division Reports

At the Summer Meeting of the Society last May nine new standards or recommended practices, six revisions

and two cancellations of existing standards were submitted by eight Divisions and approved by the Society. At the time of preparing this report 13 new standards or recommended practices, 14 revisions and 3 cancellations of existing standards had been prepared by 11 Divisions for submission to the Society for approval at the Annual Meeting in January, 1931.

These reports resulted from 23 Division and Subdivision meetings held during the year, aside from a large proportion of the work that was done by correspondence with the Division members.

S.A.E. Handbook

The 1930 edition of the S.A.E. HANDBOOK, issued early last March, included all S.A.E. specifications current at the close of the Annual Meeting in January, 1930. The semi-annnal Supplement containing the new and revised specifications approved at the Summer Meeting at French Lick Springs, Ind., was issued in July.

Aside from the standards and recommended practices published in the S.A.E. HANDBOOK, the Society has also issued four S.A.E. Production Engineering Standards as separate pamphlets, three of which were revised in January, 1930, and reprinted.

Sectional Committees

During the year the Society was a sponsor for 10 Sectional Committees under the American Standards Association and represented on 18 others that were of interest to a smaller degree to the automotive industry. The most noticeable increase in the scope of sectional committee work was the addition of a number of new projects under the Sectional Committee on Small Tools and Machine-Tool Elements.

International Standardization

International activity in standardization continues to grow although, so far as the Society is concerned, no official action was taken during the year on any international projects. The Society was officially represented at international standardization conferences on aircraft held at The Hague last January and at Milan, and Paris on automobile standardization in April and May.

During the year it has been indicated that probably standard specifications relating to motor-vehicle operation and maintenance will be developed before long for adoption and publication in much the same way that the present design and production engineering standards are formulated and adopted.

General Activities

As in previous years the Society has had representatives on approximately 40 committees of other national organizations, governmental departments and bureaus and similar groups that are dealing with subjects involving standardization. Many of these projects relate more particularly to general industry but all of them have some bearing on the interests and practices of the automotive industry.

The plans of the Society for standardization activities during the coming year lie along the general lines already established for many years.

A. BOOR,
Chairman.

Treasurer's Report

THE 1929-1930 fiscal year closed with the Society in a very favorable financial position as the accompanying balance sheet and income and expense statement show.

In brief, the total income of the Society showed a gain of $27,054.64 over that of the previous year, while expenses increased $33,918.99. This left an unexpended income at the close of the year of $11,842.35 or $6,864.35 less than that of the previous year. Even with this decrease in unexpended income and a considerable decrease in the accounts payable at the close of the year the Society's investments in securities were increased by $1,024.25.

In the last few months of the calendar year the Finance Committee has been very active in urging that the strictest of economies be adopted in the budgeting of expenses for the coming year and active steps have been taken to guide the work of the Society along the most effective and economical lines befitting the present general financial conditions.

C. B. WHITTELSEY, JR.,
Treasurer.

COMPARATIVE BALANCE SHEET AS OF SEPT. 30, 1929, AND SEPT. 30, 1930.

Assets	1930	1929
Cash	$ 9,728.67	$13,523.59
Accounts Receivable	20,426.12	27,603.10
Securities	215,601.25	214,577.00
Accrued Interest on Securities	3,555.41	3,480.41
Inventories	827.90	1,038.95
Furniture and Fixtures	7,067.63	1,000.00
Items Paid in Advance, Charges Deferred	7,253.69	5,332.88
TOTAL ASSETS	$264,460.67	$266,555.93
Liabilities and Reserves		
Accounts Payable	$5,151.80	$17,176.15
Dues and Miscellaneous Items Received in Advance	16,459.25	17,691.49
Reserves Set Aside for Anticipated Expenses	1,242.41	1,923.43
General Reserve	229,764.86	211,058.16
Net Unexpended Income	11,842.35	18,706.70
TOTAL LIABILITIES AND RESERVES	$264,460.67	$266.555.93

INCOME AND EXPENSE AND BUDGET COMPARISON FOR 12 MONTHS, ENDED SEPT. 30.

Income	1930	1929	Budget
Dues and Subscriptions	$101,135.50	$96,148.75	$97,000.00
Initiation Fees	18,730.00	18,975.00	18,000.00
Affiliated Appropriations	5,000.00	7,500.00	5,000.00
Interest and Discount	11,528.61	10,647.97	12,000.00
Advertising Sales—S.A.E. JOURNAL	268,118.00	244,869.50	260,000.00
Advertising Sales—S.A.E. HANDBOOK	9,500.00	12,000.00	12,000.00
Miscellaneous Sales	17,541.86	14,970.61	16,000.00
Profit from Sales of Securities	638.75	26.25	....
TOTAL INCOME	$432,192.72	$405,138.08	$420,000.00
Expense			
Research	$17,617.57	$18,264.56	$16,030.00
Standards	17,827.69	22,990.79	21,130.00
Publications	116,556.17	98,609.40	103,630.00
Meetings	41,213.59	35,807.79	40,050.00
Sections	13,625.45	11,547.48	15,420.00
Professional Activities	379.36	584.67	4,000.00
Cost of Membership Increase	13,102.40	12,674.92	14,050.00
Cost of Advertising Sales—S.A.E. JOURNAL	85,482.78	74,804.21	77,410.00
Cost of Advertising Sales—S.A.E. HANDBOOK	2,004.63	2,699.47	2,700.00
Cost of Miscellaneous Sales	8,597.91	7,215.46	6,460.00
General Expense	103,942.82	101,232.63	106,200.00
TOTAL EXPENSE	$420,350.37	$386,431.38	$407,080.00
Net Unexpended Income	$11,842.35	$18,706.70	$12,920.00

Annual Meeting Report

(*Continued from p. 139*)

Concerning the importance of rubber in the automotive industry, Mr. Lee said in part that approximately 8 per cent of the total cost of the car is in rubber. Therefore, he believes that this material should be given its proper place in engineering departments, and that the problems of design and specification of rubber parts should be analyzed in the same manner as for other components of the car.

The conditions which Mr. Lee's company has found important in connection with this choice of rubber qualities or stocks are: Temperatures and fixed compression-loads; abrasion; mechanical deflection or deformation; proportions between movements and volume; appearance or finish; chemical reactions on rubber and of rubber on other parts; manufacturing procedure; dimensional variations; and change of physical properties due to aging. He then analyzed these conditions in detail.

Rubber-Usage Increase Noted

In the prepared discussion submitted by Colin Macbeth, he stated in part that when adopting rubber as a component part of an automobile it has to prove itself to Mr. Lee as being suitable to the job and to be in such shape that it can be handled as a foolproof item in the hands of the average mechanic. It appeared to him that Mr. Lee goes farther than the average automobile engineer in specifying his requirements as regards physical properties of rubber items, instead of leaving the bulk of the development work, as regards mixings, cures and the like, to the rubber manufacturers.

From observation of American automobile design there is undoubtedly, in Mr. Macbeth's opinion, a substantial increase in the use of rubber at points of attachment between sprung and unsprung parts; but, in this respect, the European use of Silentbloc Shackles—even by very conservative producers—goes to make the European car a "grease-gunless" job. Further, he said that there appears to be little that the properly proportioned rubber mixing cannot do today, so far as oscillating bearings are concerned. He enumerated all the locations on a motor-vehicle where the increased usage of rubber is desirable.

Tires and the Rim Riddle

The objective method of problem analysis, which aims to replace "I think" with "I know," should be applied to the solution of the automotive industry's rim-riddle, according to Mr. Lemon. During car life, tire costs average more than thirty times rim costs. This makes rim design a major tire-problem. High speed, safety, appearance and service, focus present attention on automobile rims, wheels and tires. The history of clincher and flat-base straight-side tires and rims was reviewed.

The English pioneered the well-base rim and decided that its success depends on the nice adjustment of rim dimensions to the requirements of the tire, said Mr. Lemon. English and American international standards of drop-center rims seem likely to be adopted. German drop-center rims resemble the English standard and include a safety type of rim. The French drop-center rim and tire are not interchangeable with other European or with American equipment.

In the United States the drop-center rim was first used on Ford and on Lincoln cars, Mr. Lemon continued. The great change to the drop-center tire and rim by Chevrolet, Chrysler, Willys, Pontiac, Essex, and other quantity-production car-manufacturers in 1929 and in 1930 indicates that previous wariness of adoption has been overcome. Rim, wheel, and tire alterations are under way in proportion to the suddenness and extent of this equipment change.

Methods of putting on and removing both small and large-size tires are suggested in Mr. Lemon's paper. Rim strips and location of valve holes are discussed, and a semi-drop-base rim is described. The tabular data cover present original-equipment tire-and-rim sizes for English, German, French, and American 1931 cars. Rim profiles and dimensions are included. Opinions and experiences of American automobile engineers are given.

Mr. Lemon advanced two factors considered essential for the prolonged success of the drop-center rim in America. One factor is that tires shall mount and dismount with the same or with greater ease than that for flat-base rims. The other factor is that tire service and car-operating safety on drop-center rims shall be comparable with or better than past performance.

For light cars the public appears to have accepted the drop-center rim as a step in advance, Mr. Lemon concluded. The years of 1931 and 1932 will record car-owner reactions to the rim for larger cars. As an engineering body, honest open-minded analysis of the industry's tire-and-rim problems is certain to lead to a continued improvement of the automobile.

Drop-Center-Rim Development

Mr. Ash said in part that the rim industry, having particular reference to passenger-cars, has had a diversified

SPEAKERS, CHAIRMAN AND DISCUSSERS AT THE CHASSIS SESSION

(Top) B. J. Lemon, of the United States Rubber Co., Who Told of the Tire and Rim Riddle; R. K. Lee, of the Chrysler Corp., Who Gave a Paper on Rubber as a Vibration Absorber; C. C. Carlton, of the Motor Wheel Corp., Chairman

(Bottom) A. S. Van Halteren, of the Motor Wheel Corp., F. S. Duesenberg, of Duesenberg, Inc.; Burgess Darrow, of the Goodyear Tire & Rubber Co., Discussers; A. S. Ash, of the Kelsey-Hayes Wheel Corp., Who Gave a Paper on Drop-Center Rim Development

experience, which he outlined. After the advent of the straight-side tire, which was supposed to eliminate rim-cuts and provide a more reliable bead-construction, it became necessary to provide a rim with detachable side-flanges or rims that were split and which could be collapsed for tire removal. This type of construction has been very popular and practicable for a number of years; however, during the last few years the trend has been toward smaller rim-diameters and larger cross-section tires.

At the same time the tire diameter has been somewhat decreased to bring the car lower to the ground; or, to lower the center of gravity, Mr. Ash continued. In fact, in some cases the rim diameter has been small enough to handicap what is known as the present construction. In the case of the split straight-side rim, it is more difficult to collapse and, in the case of what is known as the "Q. D." rim, the side ring is somewhat difficult to apply and remove. These conditions, as well as features hereinafter described, have brought about the consideration of the drop-center-rim construction.

Defining the "drop-center rim," Mr. Ash said that the term has been applied to a rim having a much different cross-section than either of the plain clincher or straight-side rims. The drop-center rim is an endless rim, both side flanges being integral. The center portion of the rim between the two tire-bead seats is depressed or rolled smaller in diameter to provide what is termed a "well." This well is so formed in proportion to the side flanges as to facilitate the mounting and demounting of tires.

After enumerating the advantages of drop-center rims, Mr. Ash said that, from an engineering standpoint, it seems that drop-center rims, when properly developed, will be a great advantage to the industry.

Discussers Contribute Comments

Burgess Darrow remarked that, in his opinion, Mr. Lemon's paper creates the impression that there is a riddle in connection with tires and rims; but Mr. Darrow said that it is not a difficult riddle and is simply a straightforward development over the last 20 years, during which time only three distinct types of rim have been involved.

The clincher rim came into use very early and probably reached its highest point of usage and development about 1910 to 1915; then it decreased in favor about 1925 and finally became extinct, Mr. Darrow continued. The straight-side flat-rim came in about 1907 and gradually increased in favor until, in 1925, it was completely universal in this Country. The drop-center rim for automobiles laid dormant for 25 years; but, about 1925, it returned to its own and in 1931 it is making a strong bid for universal usage.

In conclusion, Mr. Darrow recommended that car engineers should follow the recommendations of rim and tire sizes that are furnished by the Tire & Rim Association, and should not take liberties in the way of over-sizing tires in connection with drop-center rims.

A. S. Van Halteren agreed with Mr. Lemon in regard to the trend in rim design, but qualified some of Mr. Lemon's statements in regard to the relative merits of rim and of wheel types. He said in part that in his opinion the trend toward the drop-center rim on demountable wheels for the lighter cars has not been because the drop-center rim functions better, but rather because it is lighter and can be produced for less money. In conclusion he remarked that the drop-center type of rim eventually will solve the rim riddle, and is desirable because it permits wide-section rims most economically for both the demountable-at-the-hub and the demountable-at-the-felloe wheel, according to his best judgment.

Diesel Design and Operation

Oil-Engine Development and Problems Require Two Sessions and Elicit Much Discussion

TWO sessions were devoted to the subject of Diesel Engines, the first on Thursday afternoon and the second on Friday forenoon. The papers on the subject were productive of a large volume of prepared and impromptu discussion. Two papers were presented at each session, and at the second session a Nominating Committee to nominate the Vice-President for the Diesel-Engine Activity was elected. Under the very able Chairmanship of O. D. Trieber, about 300 attendants listened attentively to the presentation by E. F. Ruehl, of I. P. Morris & DeLaVergne, Inc., of a paper on Combustion and Design Problems of Light High-Speed Diesel Engines and a paper by A. A. Lyman, of the Public Service Coordinated Transport, on the Operation and Maintenance of Diesel-Engined Motorcoaches.

Injection and Combustion Relation

Mr. Ruehl dealt in detail with the relative merits of existing types of combustion-chamber and injection systems used in present commercial four-cycle Diesel and gasoline engines and endeavored to show that the single-turbulence-chamber type offers the most promising means for obtaining high mean effective pressures at low fuel consumption. He explained the interrelation of combustion and injection processes in controlled-turbulence combustion-chambers and gave design details by means of lantern slides. He showed test results of the practical application of single-chamber principles and of a stock injection system to flexible combustion control in a recently developed high-speed four-cycle engine. He also discussed the factors that limit mean effective pressures and piston speeds and some of the mechanical problems of design, such as cooling and lubrication.

Good Results with Diesel Coach

Mr. Lyman, in a very brief paper that brought hearty applause from the audience, recited the Diesel-engine experience of the Newark, N. J., motorcoach operating company of which he is automotive engineer. The results obtained seem to presage a bright future for the oil engine in heavy-duty automotive work and a probable early development along this line. In the summer of 1929 the company imported a German Diesel truck engine that developed 70 hp. and weighed about 1400 lb. and installed it in a standard gasoline-electric 30-passenger motorcoach. As this was the first vehicle of its kind in America, it was driven to the convention of the American Electric Railway Association at Atlantic City the following October.

This vehicle was operated throughout the following winter and showed remarkable fuel economy and indicated that the Diesel-engine principal was practical for motorcoach powerplants. A later development of this engine as a motorcoach engine was imported from Germany in March, 1930, and substituted for the truck engine. It weighed 200 lb. less and developed 75 hp. at a governed speed 1600 r.p.m. The coach was operated in regular service, except for a 2000-mile round trip to the Summer Meeting of the Society at French Lick, Ind., until last fall, when it was returned to the German factory and exchanged for a later model. The third engine has been operating in city service since October, 1930.

All of these engines are of the solid-injection precombustion-chamber type and in dynamometer tests showed ability to run well on a wide range of fuels and with economical consumption at all speeds and loads. Exhaust-gas analysis showed almost perfect combustion, with a negligible carbon-monoxide content. Electric heater-plugs are used for starting the engine cold, which requires about 30 to 45 sec., but are not used when the engine is warm. With the engine warm the coach is controlled exactly as with the usual gasoline engine and electric drive. Mr. Lyman

stated that the coach has been operated and maintained by three different garages and driven by a number of operators at each garage and that the drivers do not notice the difference.

The road performance of the coach has been as good as that of any gasoline vehicle, said Mr. Lyman, no trouble having been experienced with the engine's idling. Fuel consumption has been 60 to 70 per cent of that of gasoline coaches operating under identical conditions, and the price of the fuel is considerably less than that of gasoline. Cooling water and exhaust temperatures are noticeably lower than with gasoline engines, and the engine accessories have given satisfactory results. Such trouble as has been experienced with the fuel equipment has been due to air in the injection pipes.

Mr. Lyman said in conclusion that more than one year's operation has been very encouraging and demonstrates that great progress has been made abroad in the development of automotive Diesel engines.

Tells of Successful High-Speed Engines

Commenting on Mr. Lyman's paper, Chairman Treiber stated that he had just returned from Europe and while there had driven motorcoaches and trucks powered with the same kind of engine used in the American motorcoach. One thing he noticed was that the engine has a high torque at low speeds and runs very smoothly. The engines emitted no smoke whatever. He was informed that about 500 engines of the same type are running in buses and trucks in Europe. He remarked that we are going to have more of them in this Country pretty soon. For the next Diesel-engine meeting of the Society, he suggested that a paper be given on the thermodynamics of oil engines and another on a theoretical discussion of fuel oil. Because of the large variety of types, the time is coming, he said, when we shall have to qualify or eliminate the word "Diesel" and find some other name for the oil engine.

At least six reputable, experienced manufacturers in Europe are producing Diesel engines that are susceptible of application to trucks and coaches, asserted Oliver F. Allen, of the General Electric Co. Certainly more than 1000 are in regular operation on the Continent and in England; there are several makes of which from 200 to 500 are in operation. The general understanding of the term "Diesel engine" abroad is that it means an engine of the compression-ignition type, irrespective of where its maximum pressure occurs or how the fuel is injected. If the high-speed fuel-injection engine is to take the place of the gasoline carbureter engine in automotive work, injection pumps must be developed to run at higher than 1000 r.p.m. Supercharging should be seriously considered, he said, for improving the volumetric efficiency and assuring adequate scavenging. In conclusion, Mr. Allen showed lantern slides of and hastily described two European aircraft Diesel engines that he said might be added to the Packard radial air-cooled engine. These are the Beardmore eight-cylinder in-line water-cooled and the Junkers six-cylinder double-piston two-stroke water-cooled aircraft engines. He also showed and gave data on an English Acro-system six-cylinder four-cycle engine just brought out that operates at 3000 r.p.m., a McLaren-Benz developed in England for locomotive service, a Modaag-Krupp two-stroke general-purpose engine and a Peugeot-Junkers motor-truck engine in regular production in France.

Believes Turbulence Important

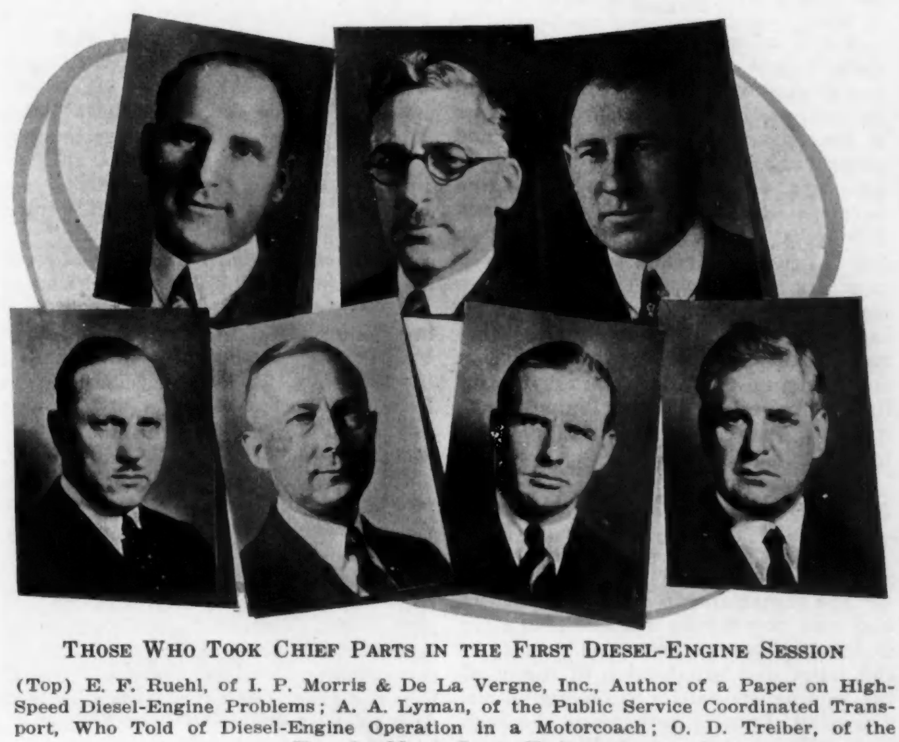
The importance of the influence of turbulence on spray design and injection pressure is not sufficiently understood, according to J. E. Wild, of the Robert Bosch Magneto Co. He maintained that, unless sufficient turbulence is provided for, the task of effecting correct fuel distribution is imposed on the injection system and that more nozzle orifices of smaller diameter are required, together with higher injection pressures, which results in clogging and reduced life of the pump and its drive members. He believes that pressures for small high-speed single-chamber engines should not exceed 4000 lb. per sq. in.

Time lag of ignition was discussed briefly by Chairman Treiber and Mr. Ruehl, the former remarking that it is one of the most important factors and that some day we shall know much more about it.

Results with Electrically Controlled Injection

An interesting dissertation on the fineness of the fuel particles and the time element for igniting and burning the sprayed fuel was given by W. F. Joachim, of the Westinghouse Electric & Mfg. Co., who thinks that eventually we may find that injection in the high-speed engine is almost like an explosion. In that case, the spray may have to be designed so as to dispense with the ultra-rich core.

Brooks Walker told of results in some Diesel-engine development work done in his California laboratory. He and his brother, Clifford Walker, developed a fuel system in which the pressure in the line varies as the square of the engine speed and gives exact metering over a variable speed with a line injection-system and constant angle of pressure injection. They also developed a constant-time injection period, both mechanically and electrically controlled. With electrically controlled injection valves, he said, they have operated a 2⅞-in. bore engine at a maximum speed of 4500 r.p.m. and have tested the nozzles up to a speed corresponding to 22,000 r.p.m. of a four-cycle engine. They have operated a full-Diesel engine of 186-lb. compres-



THOSE WHO TOOK CHIEF PARTS IN THE FIRST DIESEL-ENGINE SESSION

(Top) E. F. Ruehl, of I. P. Morris & De La Vergne, Inc., Author of a Paper on High-Speed Diesel-Engine Problems; A. A. Lyman, of the Public Service Coordinated Transport, Who Told of Diesel-Engine Operation in a Motorcoach; O. D. Treiber, of the Hercules Motor Corp., Chairman

(Bottom) S. F. Sandell, of the Sandell Motor Co., J. E. Wild, of the Robert Bosch Magneto Co.; Brooks Walker, of California; and Oliver F. Allen, of the General Electric Co., Who Submitted Discussion

PARTICIPANTS IN THE SECOND DIESEL-ENGINE SESSION

(Top) W. F. Joachim, of the Westinghouse Electric & Mfg. Co., Chairman; E. T. Vincent, of the Continental Motor Co., Who Delivered a Paper on Compression-Ignition-Engine Research; A. J. Poole, of the Robert Bosch Magneto Co., Who Read a Paper by C. G. A. Rosen, on the Mobile-Type Diesel Engine

(Bottom) H. S. Butler, of the Standard Oil Co. of New Jersey; Wolfgang Von Dorrer, of Detroit; Harte Cooke, of the McIntosh & Seymour Corp.; and Robertson Matthews of Detroit, Discussers

sion pressure and are getting 110 hp. from a 5 x 7 engine at 1400 r.p.m. with electrically controlled injection.

Supercharged Two-Cycle Injection Engine

A reel of motion pictures of a two-cycle V-type air-cooled aircraft engine was next shown and explained by S. F. Sandell, of the Sandell Motor Co. This is scavenged by a Roots blower and supercharged. The fuel is injected. It has four 4¼ x 5¼-in. cylinders and develops 125 hp. at 1500 r.p.m. and 175 hp. at 1650 r.p.m. The weight is 380 lb., complete ready for flight. The injectors spray the fuel into a passage leading to a small poppet-valve opening into the cylinder. The compression ratio is 4.7:1. It has been run on fuels ranging from Aviation ethyl gasoline to fuel oil of 32 deg. Baumé gravity. The fuel consumption is from 0.52 to 0.53 lb. per b.hp-hr.

Second Diesel-Engine Session

FRIDAY morning's continuation of the Diesel-engine program was under the chairmanship of W. F. Joachim and was noteworthy for the character of the two papers presented, which, to the relief and satisfaction of many of the leading specialists in oil-engine engineering, frankly recognized the lack of knowledge that is impeding the successful development of light high-speed engines.

The presentation by E. T. Vincent, of the Continental Motors Corp., of a review of research on compression-ignition engines was highly commended by virtually all of the discussers. The paper by C. G. A. Rosen, of the Caterpillar Tractor Co., covering a survey of the status, difficulties and prospects of the mobile-type Diesel engine, which was read in the absence of the author by A. J. Poole, of the Robert Bosch Magneto Co., was also highly complimented for the author's frank admission of the problems still confronting the research and designing engineer.

The session opened with a brief business meeting of the Diesel-Engine Activity for the election of a Nominating Committee to choose a nominee for Vice-President. The election resulted in the election of O. D. Treiber, A. W. Pope, Jr., Harte Cooke and R. J. Broege as members of the Committee and Neil MacCoull and J. E. Wild as alternates.

In introducing the speakers, Chairman Joachim stated that Mr. Vincent was formerly connected with the Beardmore company in England and was a co-developer and designer of the Beardmore aircraft engine and rail-car engine. Mr. Vincent reviewed the research work done in England and in this Country in recent years and stated that the great present need is a knowledge of methods to be used in designing efficient injection systems and combustion-chamber shapes so as to realize the potentially high power-output of the oil-engine cycle. He illustrated and discussed the several types of oil engine, classified as direct injection, precombustion chamber and divided combustion chamber, telling of their principal advantages and disadvantages. In conclusion he predicted that the future compression-ignition engine for automotive applications will embody the direct-injection system, probably in some modified form, and that, as our knowledge of injection and combustion improves, it will become possible to predict performance of the engine with greater accuracy than is now possible with the gasoline engine. The weight, he said, should not be more than 10 or 15 per cent greater than that of a corresponding gasoline engine of the same class, and the weight per horsepower should tend to become less than that of the present gasoline engine. The question of detonation will become more prominent than it has been, and this offers a wide field for the research worker.

Handicapped by Preconceptions

Mr. Rosen's paper drew comparisons between the mobile-type Diesel engine and the automotive gasoline engine, the object of the author being to cull those factors of oil-engine design that assure good operating quality. The greatest handicap encountered by the oil engine, he asserted, is the erroneous preconceptions of operating conditions. The designer, he holds, must turn to pure science for fundamentals and investigate qualitatively the great accumulation of research data on the internal-combustion engine to determine the bearing of combustion theory on operating results. Unification of the best features and types and a happy compromise of the desirable characteristics are needed to increase the manufacturing and sales possibilities.

Discussers Give Interesting Information

Prepared discussion on the two papers was presented by Robertson Matthews, research and development engineer of Detroit, who advocated more turbulence and also vaporization of the fuel, as the time element is a vital factor in high-speed work. He looks forward to seeing some work done on regulation of the time of compression ignition. He argued the need of an especially prepared oil-engine fuel and asked how many decades must pass before we shall look askance at engineers trying to get 3000 r.p.m. out of an engine using gas-oil and trying to compete with the carbureter engine. He also suggested abandonment of the name Diesel as a type designation and the promotion of an S.A.E. Activity to be known as the Advanced-Engine Development Activity. Another proposal was for someone to bring about the provision of a sum of $25,000 or $50,000 as an incentive for some engineer to develop a satisfactory combustion indicator.

Slides of a new European engine known as the Oberhausti were shown by Wolfgang von Dorrer, of Detroit, who explained it as having a combustion-chamber that is a compromise between the precombustion-chamber and the air chamber of the Acro system, with the fuel injected by an atomizer into a shell surrounded by warm air. The thermal pressures are low and a four-cylinder engine works very satisfactorily, developing 70 hp. at 1250 to 1300 r.p.m. The compression ratio is 14.9:1, the mean effective pressure 72 lb. per sq. in., the compression pressure 441 lb. per sq. in. and the terminal pressure 682 lb.

Mr. Treiber remarked that he had seen and run tests on two or three of the Oberhausti engines in Austria as high as 3000 r.p.m. at 80 lb. m.e.p. and they ran smoothly, with clean exhaust and a very satisfactory fuel consumption. He said that he thinks this is going to be a coming engine in lightweight automotive work, as it is no heavier than a conventional European gasoline engine.

An item of human interest was contributed by Harte Cooke, of the McIntosh & Seymour Corp., who, as an illustration of the possibilities of overcoming obstacles, stated that Hesselman, who has done so much in the engine field, had lost both legs in a train accident and had to get around on artificial legs, yet by persistence has done wonderful research work on Diesel engines. With all of our facilities, we should be able to find out many of the facts we need to know about oil engines, particularly the initiation and process of combustion.

Papers like those of Mr. Vincent and Mr. Rosen are most refreshing, asserted J. L. Goldthwaite, of the Allison Engineering Co., because the authors recognize that the difficulties are not solved. "None of us knows a doggone thing," he said, "about the details of what goes on in a Diesel engine or in an injection pump or any injection system." He said that he could absolutely prove his statement. He referred to "sloppy" views that are widely held and lead to false conclusions and a great amount of expensive work by each investigator to find out that they are wrong. We must get instrumentation on these things. His own company built a stroboscope with three ½-watt Neon tubes at a cost of $1.50 and in one day uncovered more information than six months of theoretical study will show. A stroboscope will show amazing facts about the fuel spray, he said. Indicator cards taken by different men with different instruments are not comparable, as they can vary by 75 per cent. We must have accurate indicators and all kinds of instruments. "Above all," he concluded, "we must divide our information into two classes; one, 'I know,' and the other, 'I don't know.' Between them will be a gap represented by the huge number who 'think I am probably wrong.'"

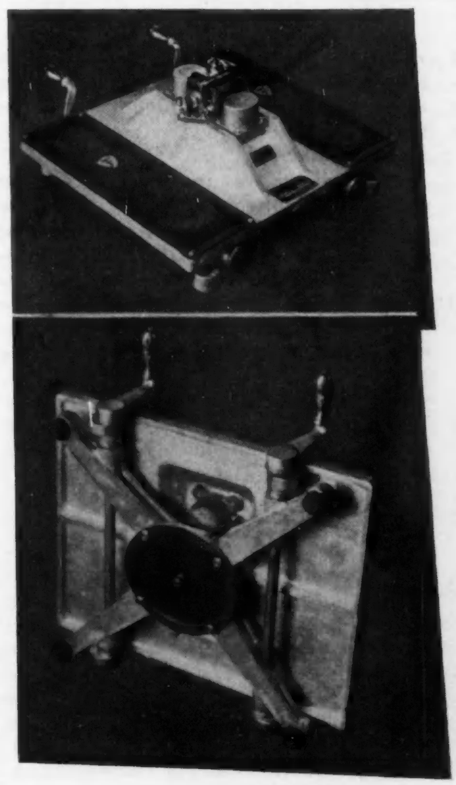
One of the most important problems, which is not generally realized, according to W. H. Butler, of the Standard Oil Co. of New Jersey, is that of fuels. Two classifications of fuel have to be used in the high-speed engine, both in the distillate range. One ignites and burns very rapidly but too little of it is available. The other ignites very slowly, increasing the ignition lag, and results in detonation, after-burning, high exhaust temperatures and smoke. The cam contour to give injection over a longer period, referred to by Mr. Vincent, is highly important, as these slow-igniting fuels are the ones the oil engines are going to get, unless special products that cost more are to be used.

The session ended with a summing up of the discussion and answers to it by Mr. Vincent and favorable comments on Mr. Rosen's paper.

General Development Session

Zinc and Zinc-Alloy Usage Considered—Records of Riding-Quality Measurement Analyzed

TWO SUBJECTS were considered at the General Development Session held Friday morning, Jan. 23. R. M. Curts, of the New Jersey Zinc Co., presented a paper on the Use of Zinc and Zinc Alloys in the Automotive Industry, and his paper was afterward discussed. Riding-Qualities was the second subject presented, and two papers bearing this title brought the subject up to date. The first of these was by Dr. Fred A. Moss, of George Washington University, and had reference to a "wabble-meter." The second riding-quality paper was prepared by Ammon Swope and G. C. Brandenburg. Chairman E. S. Marks presided over the 75 members and guests who were present. A business session of the Passenger-Car Activity was included in the proceedings.



WABBLE-METER DEVELOPED FOR MEASURING RIDING FATIGUE, WHICH WAS DEMONSTRATED AT THE MEETING

Zinc and Zinc-Alloy Use

Mr. Curts said in part that the automotive engineer has two primary and essential responsibilities (*a*) to make possible the manufacture of better cars without materially increasing the cost thereof; and (*b*) to reproduce with greater economies the high standards of design and performance existing in the present-day product. Improvements must be made for the most part without adversely affecting the cost sheet. Paring costs by forcing down the price of raw material or accessory parts used in assembly to the point where there is no legitimate profit to the supplier is certainly not a wholesome way to effect economies in motor-vehicle manufacture. Economies must come through the substitution of new manufacturing processes or by a better understanding of such engineering materials as may show an economic advantage without cheapening the final product. He stated that it is the purpose of the paper to discuss the metal zinc as an engineering material. To this end he reviewed briefly the part zinc and its alloys have played in the past, and discussed recent development in zinc-base alloys which have greatly enlarged their field of use in the automotive industry.

Among the various specific subjects treated by Mr. Curts were brass, nickel and silver, rolled zinc and rolled zinc-alloys, zinc wire, extruded zinc shapes and die-castings. He said that in the early days of die-casting, alloys composed principally of tin or lead were used almost exclusively, but that castings made of these alloys did not possess the necessary strength and their

PRINCIPALS AT THE GENERAL DEVELOPMENT SESSION

(Top) F. A. Moss, M. D., of the George Washington University, Who Reported on Riding-Qualities Research; R. M. Curts, of the New Jersey Zinc Co., Who Gave a Paper on Zinc and Zinc Alloys; Ammon Swope, of Purdue University, Who Gave a Paper on Riding-Qualities Research

(Bottom) C. S. Keggereis, of the Tillotson Mfg. Co., E. S. Marks, of the H. H. Franklin Mfg. Co., and P. W. DesRoches of the *Automobile Trade Journal*, Discussers

use was greatly restricted. Zinc was tried and found to have certain advantages and, finally, a special zinc alloy was adopted. Shortly after this the so-called high-grade zinc was introduced.

After the discussion on die-cast zinc-alloyed gears, Mr. Curts entered upon a discussion of zinc alloys for body hardware and other equipment, recent improvement in zinc alloys, and data on the zinc-aluminum-alloy systems. Heat-treatment of zinc-base die-casting alloys, water-vapor tests, the disastrous effects of contamination, and the physical tests that can be applied to die-casting alloys were considered in some detail. Mr. Curts' paper also described the use of inserts in zinc-alloy die-castings, plating methods, cleaning and other procedures, the nickel-plating process, as well as the subjects of enameling, japanning and lacquering.

In conclusion, Mr. Curts summarized his paper by saying that metallic zinc is used in the automotive industry for electro-galvanizing; as a constituent of brass; as rolled sheet and strip for a variety of fabricated parts of which running-board molding heads the list; and in the production of a great number of die-cast parts. The marked improvement in both rolled zinc-alloys and zinc die-casting alloys has done much to stimulate added interest in this white, non-ferrous metal, the price and properties of which lend themselves well to effect economy without jeopardizing quality.

Not only have improvements been made in the physical properties of the various zinc-alloys, said Mr. Curts, but the application of attractive and durable plated-finishes can now be accomplished without difficulty. The number of parts on the automobile which are made of zinc or zinc alloys is increasing annually. Additional investigations are being undertaken to produce still other zinc alloys with suitable properties for use in a wider range of automotive parts.

Die-Casting Industry Progress

C. S. Kegerreis traced in brief detailed prepared discussion the development and phenomenal growth of the die-casting industry in the last several years. It seems to him that the whole situation can be summarized under three classifications; namely, (*a*) use of alloys of specified purity, (*b*) in dies properly gated and vented, and (*c*) with a production-casting control which obviates unauthorized use of scrap metal.

Philip W. DesRoches raised several questions in connection with the use of die-castings for refrigerator-compressor work, since temperature changes of 50 deg. cent. (90 deg. fahr.) are obtained almost every time the compressor starts to operate. These were answered by Mr. Curts.

Riding-Quality Study Outlined

After saying that automotive engineers have been designing springs, shock-absorbers, different kinds of cushions and special kinds of tires to produce better riding-qualities and that they have succeeded to a degree, Dr. Moss said that the methods used had been of the cut-and-try type. The effort made in the work that he and his assistants have been doing was to determine how these changes of parts in an automobile affect the individual who rides in the car, so far as his physiological condition is concerned, and then to ascertain what his reaction is concerning the degree of discomfort he experiences. Various accelerometers have been devised to measure changing conditions as to the car itself, but another instrument was needed to measure some of the changes in the individual while riding over long distances.

Dr. Moss described tests made of individuals to ascertain their physiological condition at the beginning of tests that were made, and then described and demonstrated a device called a "wabble-meter," which can be carried in a car, and will record the reactions of the individual before and after riding in the vehicle.

This instrument results from the development of the principle that man is unstable inherently, and constantly is transferring his weight automatically from one foot to the other in an effort to maintain his balance. When an individual steps upon the platform which is held rigid by small cams and these cams are then released to allow the platform to become unstable, the person under test has a tendency to wabble. The device has the equivalent of two over-riding clutches, one of which measures the fore-and-aft motion; the other measures lateral motion. If the person stands steadily, the over-riding clutch neither works fore nor aft; but if the person moves up or down or sideways, the movement is recorded and can afterward be analyzed from the chart record.

Results of Steadiness-Meter Tests

The studies reported in the paper by Ammon Swope and G. C. Brandenburg resulted from an effort to find what determines the comfortable riding-qualities of an automobile by means of a device called a "steadiness meter." The interpretation of the data is statistical. The calculations were made by a trained statistical clerk with the aid of the necessary machinery and tables ordinarily used in that field.

In the discussion, Prof. H. M. Jack-

lin said in part that the first thing that a new-born baby does is to gasp air into its lungs; the second is to reach for and clutch something. Some times these two events are concurrent. So, in adopting the steadiness meter that they have here presented, he said, Messrs. Swope and Brandenburg have gone back to just about the most instinctive movement that we have. Certainly it is not an acquired habit, as is standing. They have carefully gathered statistical data as to the instrument's reliability, with the result that they and everyone else should be satisfied that the results mean something very accurately and definitely. But after 160 passenger-trip records of results, they are not yet prepared to say that they are measuring steadiness as related to riding-qualities. Other comments relating to correlating the results obtained with the steadiness meter were made, by W. E. Lay, G. L. McCain and Mr. Swope, as regards this instrument's connection with riding-quality measurement.

Passenger-Car Business-Session

At the regular business session of the Passenger-Car Activity that was convened just prior to the presentation of the papers at the General Development Session held Friday morning, Jan. 23, Chairman E. S. Marks announced the purpose of the business to be the election of the Nominating Committee for the nominating of a Vice-President of the Society in charge of the Activity for 1932.

On motions duly seconded the following men were nominated and elected members of the Passenger-Car Activity Nominating Committee:

J. B. Macauley, Jr.
G. L. McCain
Maurice Olley
J. A. Anglada

Also on motions duly seconded, the following men were elected as alternates:

Walter C. Keys
W. S. James

The business session thereupon adjourned.

Heavy Detonation Symposium

Many Phases of Knock Problem Dealt with in Two Groups of Papers and Discussion

"THIS meeting marks another important milestone on the road to the solution of the problem of detonation," declared R. E. Wilson, of the Standard Oil Co. of Indiana, chairman of the Detonation Symposium Session. "We know how to control most of the variables in engine testing—humidity, temperature, carbureter settings, and methods of measuring the sound which a knocking engine makes."

Dr. Wilson pointed out that ever since Kettering and Midgley, of the General Motors Corp., first showed, more than a decade ago, that knocking was not preignition but a separate phenomenon dependent largely upon the character of the fuel, and that it limited the compression and hence the efficiency of automobile engines, automotive and petroleum engineers have been working on various phases of this problem.

Three Aspects of the Problem

There have been three aspects in the development and the solution of this detonation problem: first, the development of better fuels, which has made striking progress, particularly in the last few years, both by the addition of tetraethyl lead and by the use of improved cracking methods and the selection of special stocks to make antiknock fuels of much higher quality than were available before. Not only are there many fuels of much higher quality than any which were available eight years ago, but the average antiknock properties of the fuels marketed in this Country show a marked increase over the same period.

The automotive engineers, on their part, have done a great deal to develop improved designs of engines to utilize these fuels efficiently, because, since antiknock fuels necessarily cost more than ordinary fuels, to get the value out of them the engines must be built to utilize them more efficiently. Marked progress has been made in that direction, the average compression-ratio coming up gradually in spite of the fact that the simultaneous progress toward larger engines would tend to decrease the compression ratio.

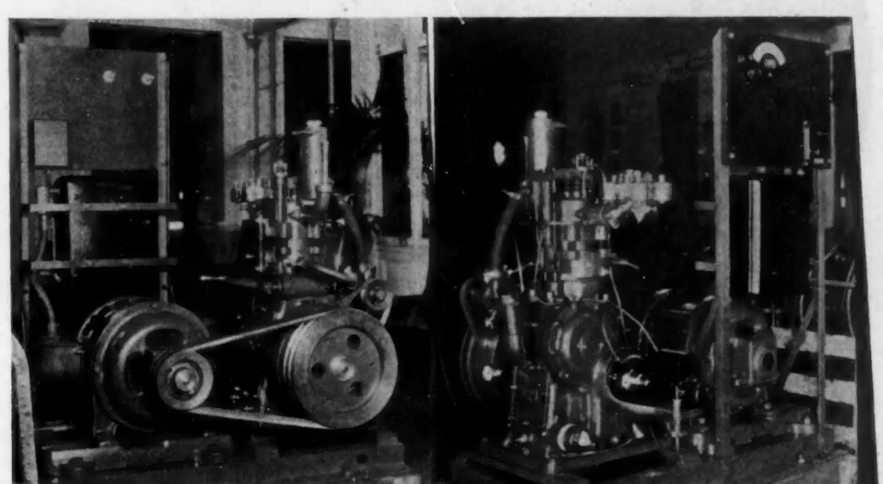
The third aspect of the problem of detonation is one on which it may seem to the outsider that progress has been much slower; that is, the development of improved, accurate and reproducible methods of testing the antiknock quality of different fuels. One of the reasons for the slow progress has been the reluctance on the part of many to accept, what now seems to be more or less inevitable, the fact that the only satisfactory method of measuring detonation is actually to test the fuel in an engine of a design similar to that of the automobile engine.

Suitable Test-Engine Developed

The development of a suitable engine was the first task undertaken by the Detonation Subcommittee of the Cooperative Fuel-Research Steering Committee in its effort to establish a universally acceptable method and equipment for knock testing.

The progress in the design of this engine was covered in detail by H. L. Horning, of the Waukesha Motor Co., in his paper entitled The Cooperative Fuel-Research Committee Engine, read at the meeting by A. W. Pope, Jr. The engine with the new variable-compression valve-in-head integrally cast cylinder, equipped with a specially designed carbureter, was displayed at the meeting.

The second step in the solution of the detonation problem was solved as a result of the preliminary work of the Detonation Subcommittee. Upon the recommendation of the Steering Committee, the Society established as recommended practice the rating of fuels in terms of octane number, or the percentage of iso-octane in a blend of iso-octane and normal heptane required



Test Engine Developed for Cooperative Fuel-Research as Improved with Four-Float-Bowl Carbureter and Variable-Compression Head Adjustable by Means of a Crank

to match the detonation characteristics of a given fuel.

However, the problem is still not entirely solved, for, unfortunately, if the same fuel is tested under a variety of different conditions, different octane numbers result depending upon those conditions and there cannot be a final solution of the problem until the effect of many variables such as temperature, humidity and carbureter setting have been accurately determined.

The papers presented at the Annual Meeting symposium represented contributions on these subjects from oil and automobile-company laboratories throughout the Country and from the Bureau of Standards as part of the cooperative program sponsored by the Cooperative Fuel-Research Steering Committee. The symposium included

CONTRIBUTORS TO THE SYMPOSIUM AND DISCUSSION ON DETONATION

(Top) R. Stansfield, C. H. Sprake and C. H. Barton, British Delegates from the Institute of Petroleum Technologists, Who Gave a Report on Knock Rating of Motor Fuels

(Center) H. L. Horning, of the Waukesha Motor Co., Who Described the Cooperative Fuel-Research Test Engine; Donald B. Brooks and Noel R. White, of the Bureau of Standards, Co-Authors of a Paper on Effect of Humidity and Temperature; R. E. Wilson, of the Standard Oil Co. of Indiana, Chairman

(Bottom) Dr. Graham Edgar, of the Ethyl Gasoline Corp., Who Presented a Paper on Effect of Jacket and Cylinder-Head Temperature on Knock Rating; Daniel Roesch, of the Armour Institute of Technology, and D. P. Barnard, 4th, of the Standard Oil Co. of Indiana, Discussers

nine formal papers and four contributions in the form of prepared discussion.

British Engineers Make a Report

A paper entitled, Knock Rating in Motor Fuels, by C. H. Barton, of the Asiatic Petroleum Co.; C. H. Sprake, of the Anglo-American Oil Co.; R. Stansfield, of the Anglo-Persian Oil Co., and O. Thornycroft, was presented by Mr. Stansfield. A report presented a year ago before the Society dealt with tests carried out in the research laboratories of the three companies represented in the group with the object of determining the agreement that could be obtained on three widely different designs of test engine when the gasolines in common use on the British market were examined. It was realized that this range was comparatively narrow but the results obtained encouraged belief that reasonable agreement might be reached with a greater range of fuels. The results of a second series of tests, using the Ricardo 2-liter E-35, the Delco and the Armstrong engines, were reported in the present paper.

Mr. Sprake discussed the points raised by the subcommittee of the Institution of Petroleum Technologists concerning proposed conditions for knock-testing procedure, and Mr. Barton presented a brief summary of the comments of Mr. Thornycroft, deputy director of research of the British Air Ministry, setting forth the necessary engine and equipment requirements for conducting satisfactory knock-rating tests on aircraft fuels. S. D. Heron, of the Air Corps at Wright Field, commented briefly on this summary.

Humidity and Air-Temperature Effect

Confusion may possibly be avoided by restating the title of the paper as the Differential Effect of Humidity and Air Temperature on the Detonation of the Primary Standards and Several Materials Suitable for Secondary Standards, N. R. White pointed out in presenting the paper prepared by D. B. Brooks, G. C. Rodgers and himself, all of the Bureau of Standards. In the course of the work reported upon in this paper, four scales composed of such materials were investigated and curves showing the effect of humidity and air temperature on the knock ratings were exhibited, with the general conclusion that the effects of atmospheric conditions on materials being considered for use as secondary standards cannot be neglected.

Changes in jacket temperature definitely affect the relative antiknock value of fuels; when comparing benzene and tetraethyl-lead blends with a fixed spark-advance the results obtained at different compression-ratios will differ; adjusting the spark advance for maximum power minimizes compression-ratio variations; and, although all results may be functions of the cylinder-head temperature alone, the data are not sufficiently complete to be conclusive, were the conclusions reached by Dr. Graham Edgar, of the Ethyl Gasoline Corp., as a result of the investigation reported in his paper entitled, Effect of Jacket Temperature and Cylinder-Head Temperature upon Relative Knock-Ratings.

Rating Affected by Lubricating Oil

Stating that variation in knock-testing results with a relatively high oil-consumption is partly due to the oil itself, a series of tests conducted at the laboratory of the Standard Oil Development Co. was described by H. R. Stacey, of that company, in his paper on The Effect of Oil Consumption and Temperature on Octane-Number Ratings. Conclusions drawn by the author were that the error due to different rates of oil consumption and variation of oil temperature may be as great as one octane number and is not affected by the kind of oil used. Recommendations that the oil consumption be kept at the minimum for safety and good operation and that the oil temperature be kept constant at as low a value as is consistent with good lubrication were made.

Discussion on this topic was submitted by Prof. Daniel Roesch, of the Armour Institute of Technology, who showed slides representing a series of tests made upon a four-cylinder automobile engine showing apparent octane numbers under changes of air-inlet and jacket-water temperatures.

D. P. Barnard, 4th, of the Standard Oil Co. of Indiana, also presented prepared discussion on this subject under the title, Some Observations in the Detonation Testing of Aviation Fuel at High Temperatures, which he presented in an effort to clear up any misunderstanding as to the application of the work of the Detonation Subcommittee, which has been confined to motor gasolines and to detonation-testing conditions applicable to motor fuels. Mr. Stansfield contributed some notes from his experiences along the same line.

SECOND GROUP OF DETONATION AUTHORS AND DISCUSSERS

(Top) J. M. Campbell and W. G. Lovell, of the General Motors Corp. Research Laboratories, Co-Authors with T. A. Boyd (Lower Center) of a Paper on Influence of Carbureter Setting and Spark Timing

(Bottom) J. B. Hill and H. T. Huf (Upper Right), of the Atlantic Refining Co., Co-Authors of a Paper on Knock Sound Intensity; Neil MacCoull, of the Texas Co., Who Gave Papers on Time Lag and Knock-Test Methods

Second Group of Detonation Papers

The second group of papers given at the Detonation Symposium included The Influence of Carbureter Setting and Spark Timing on Knock Ratings, by John M. Campbell, Wheeler G. Lovell

and T. A. Boyd, all of the General Motors Corp. Research Laboratories. Mr. Campbell pointed out that it is generally agreed that the antiknock quality of a motor fuel is best determined by comparison with a standard or reference fuel and described an investigation showing that this comparison may be affected by either the carbureter adjustment or the spark timing or by both. Therefore, in establishing a standard method of comparing one fuel with another, some definite specification covering each of these two engine-variables must be drawn up. This specification should correspond reasonably well with conventional conditions of engine operation and at the same time with convenient laboratory technique. From the results of this study these conditions would appear to be fulfilled best by using the carbureter setting for maximum knock and the spark timing for maximum power.

Measuring knock-sound intensity by means of a microphone and vacuum-tube amplifying set was described in a paper on the Effect of Sound Intensity on Knock Ratings, by Harry F. Huf, J. R. Sabina and J. Bennett Hill, of the Atlantic Refining Co. Widely varying fuels were compared with mixtures of *n*-heptane and iso-octane at knock intensities ranging from an incipient knock to one severe enough to cause preignition. The conclusion was drawn that, for tests on the L-head Cooperative-Fuel-Research knock-testing engine, the intensity of knock at which tests are made does not affect the knock ratings if a fuel-matching method is used.

Knock-Measuring Methods and Time Lag

The formal program was concluded with the presentation of two papers by Neil MacCoull, of The Texas Co. The first was on the subject of Bouncing Pin versus Throttle Audibility, and the second, on the subject of Time Lag. As a result of the first investigation, Mr. MacCoull concluded that, with a few exceptions, there is little difference in matching fuels by either the bouncing-pin or the throttle-audibility method. Regarding time lag, the tests indicated that it is advisable to provide means to dry out the mixture between the carbureter and cylinder-block on engines used for antiknock measurement, but the author added that several other points in this connection require further investigation before a satisfactory answer to the problem can be set down.

Reprints of these papers are available at a nominal price upon request to the Society.

"I will give thee 2000 horses if thou on thy part will put riders upon them," was the text aptly quoted by Chairman Wilson as descriptive of the fuel problems confronting the automotive industry. The creator of gasoline has said to us, "I will give you many thousand horses if, on your part, you will learn how to control them and manage them." Dr. Wilson likened these horses to the Army mules that will work well under a fair load but, if run on an efficiency basis with a real load put upon them, indulge in that form of kicking, biting and dumping the load which we will call detonation. The problem which the Detonation Subcommittee has undertaken is that of providing improved harnessing for these unruly horses.

Special tribute was paid by the oil men to the part that the Society has taken during the last 10 years in forwarding the solution of this tremendous problem. Virtually every forward step has been taken by a member of the Society or by our affiliates in England and has been recorded in the S.A.E. JOURNAL.

Fuels and Lubricants Discussed

Large and Attentive Audience Hears Papers on Oil-Cooling, Hydrogenation and Lubricants Classification

WHAT DO WE know about oils? was the theme of the Fuels and Lubricants Session in the afternoon of the second day, and before the session had run its course so much information had been dispensed and discussed that the answer to the theme-question could have been stated as, "Not everything, but much more than we did three hours ago."

H. C. Mougey, of the General Motors Corp., after expressing regret that L. P. Saunders, of the Harrison Radiator Corp., had been prevented by illness from preparing or presenting his paper on Oil-Coolers and Oil-Cooling, spoke of the Society's good fortune in obtaining a paper on the same subject from W. R. Ramsaur, experimental engineer of the corporation, whom he introduced as the first speaker of the afternoon.

Importance of Oil-Cooling Stressed

Calling attention to the fact that the lubricating system of the internal-combustion engine has undergone few fundamental changes, Mr. Ramsaur pointed out that other parts of the engine have made considerable advancement, resulting in many cases in high oil-temperatures and consequently imposing additional duties on the lubrication system. Mentioning increased horsepower, increased compression-pressure and increased engine-speed as the changes which directly affect oil temperatures, the speaker discussed the following troubles caused by high oil-temperatures: (*a*) excessive oil consumption, (*b*) smoking at exhaust, (*c*) fouling of the spark-plugs, (*d*) formation of carbon in the combustion-chamber due to excess oil, (*e*) engine wear and (*f*) failure of bearings. The last-named he considered the most serious of the troubles encountered.

On the other hand, Mr. Ramsaur went into the matter of low-temperature operation, stating that without some method of oil-temperature control, from a viscosity standpoint alone, the use of a heavy oil to take care of high temperatures would produce high cranking-torque and inadequate lubrication under winter starting-conditions; whereas the use of a light oil to facilitate cranking and lubrication at low temperatures would produce the extremely undesirable condition of insufficient viscosity at high temperatures. According to the speaker, a safe course can be steered between the Scylla of dangerously high temperatures with loss of viscosity and the Charybdis of equally dangerous low temperatures with inadequate lubrication, by the use of a light oil with its viscosity and temperature controlled.

A satisfactory oil temperature-control unit, according to Mr. Ramsaur, should warm the oil when cold, cool the oil when hot, restrict the oil flow as little as possible, be as free as possible from plugging, be accessible and easily cleaned, and be capable of withstanding a continuous pressure of at least 100 lb. per sq. in. Comparing oil-coolers that use air as the cooling medium and those that use water, the author stated that, under the same conditions of temperature, the water-type cooler has a considerable advantage over the air type, because of the low specific weight and low specific heat of the air as compared with water.

Mr. Ramsaur presented slides showing data obtained from the use of air-type and water-type coolers of varying sizes, and drew the conclusion that, when tests take account of the available air temperature and velocity and the available water temperature and velocity, the water-type cooler with water at 180 deg. fahr. is comparable with the air-type cooler with air at 100 deg. fahr.

Both Cooling and Warming Desirable

Alex Taub expressed the belief that present-day engines make the use of oil-coolers absolutely essential, and Chairman Mougey added that the greatest benefit to be derived from a satisfactory temperature-controlling device is not the one usually emphasized, namely, the cooling of the oil under

summer conditions, but the aid afforded by it for starting in cold weather.

Asked to amplify this idea from a Canadian's viewpoint, Gordon McIntyre, of the Imperial Oil Refineries, said that the use of a device to regulate oil temperature, with special reference to oil warming, is an ideal thing; but, speaking for the oil men, he added that they should not let the use of such devices divert their attention from their own problem of producing an oil for winter use with flat viscosity-curve and a low cold-test.

R. N. Janeway, consulting engineer, of Detroit, felt that, though the advantages of oil-coolers with respect to warming oil in winter are recognized, the car manufacturers will be particularly interested in the cooling effect under heavy duty. He said that information regarding lubrication is confined to a range which is outside the range of present-day engine conditions and expressed the opinion that engineers need to obtain fundamental data on lubrication under the conditions that obtain in engines at the present time.

No Pressure-Velocity Relationship to Heat

R. E. Wilson, of the Standard Oil Co. of Indiana, replying to a statement to the effect that someone ought to derive a relationship between the PV of bearings and the amount of heat generated and dissipated, asserted that no such relationship will be discovered because it does not exist. He said that the speed of the bearing is important in determining the temperature, which is approximately determined by the product of the speed and the viscosity, being almost independent of the load on the bearing. However, the tendency of the bearing film to rupture is a function of the pressure on the bearing and can best be counteracted by high speed and high viscosity, the very two things that tend to cause overheating. Accordingly, said Dr. Wilson, as long as engineers lump pressure and velocity together because they are two things that cause different kinds of bearing failure, and try to measure thus the general severity of bearing conditions, just so long will they be unable to intelligently design bearings to meet different conditions of service.

Dr. H. C. Dickinson, of the Bureau of Standards, reinforced Dr. Wilson's statements, adding that much more information is available on the subject than has yet been used by the designing engineers, not only on the safe load-carrying capacity of the bearings and on the heat to be dissipated, but also on the ability of oil to dissipate heat. Stating that, after a problem has become more and more complicated, it is interesting to trace it from its comparatively simple beginnings, Dr. Dickinson looked squarely at the matter of lubrication and the question of heat dissipation from the bearings, declaring that they are really two separate problems and that the whole matter has been complicated by the attempt to do the two things at the same time. He advocated study of the matter, with the idea of caring for the two problems separately.

C. T. Doman, of the H. H. Franklin Mfg. Co., told about results obtained on Army tank engines with an oil-cooler such as Mr. Ramsaur had described.

Haslam Talks on Hydrogenation

In introducing the next speaker, Chairman Mougey said that hydrogenation is a subject about which the audience had read and heard a great deal but which had been more or less mysterious. He then presented Dr. R. T. Haslam, of the Standard Oil Development Co., who read the paper, prepared by himself and W. C. Bauer, of the same company, on Production of Gasoline and Lubricants by Hydrogenation.

In presenting his paper, which is scheduled for publication in an early issue of THE JOURNAL, Dr. Haslam briefly described the hydrogenation process and its three characteristic reactions—purification, stabilization and homogenizing—that remain unaltered in direction although they change in extent, and proceeded to discuss the possibilities of applying the process to the production of motor-fuel and lubricating oil. He stressed the possibilities offered by the process of reforming the molecular structure of petroleum hydrocarbons along directed lines to obtain products of the so-called paraffinic or naphthenic types.

His presentation included data on the actual properties and performance characteristics of hydrogenated gasolines and lubricating oils as tested in two series of laboratory tests on a White and on a Mack motor-truck engine, the latter under abnormally severe conditions.

From these tests the authors reached the conclusions that hydrogenated lubricating-oils made from common crudes are superior to the best natural lubricants now available, that high-grade naphthenic gasoline and blending stocks can be produced from relatively low-grade gas-oils, and that the hydrogenation process, when widely adopted by the petroleum industry, apparently will enable the automotive engineer to design engines that are capable of operation at greater compressions, higher speeds and higher temperatures with a resultant marked gain in efficiency.

Discussers Propound Questions

Dr. Wilson asked whether any comparisons were made between the oils mentioned in the paper and ordinary hydrocarbon oils as to their oiliness. Dr. Haslam replied that he and his co-workers had done very little work on oiliness, feeling that there were very few cases where it comes into play. Most of the bearing failures, he said, come from the break-down of the oil, not from lack of oiliness.

Replying to Chairman Mougey's question whether there is any particular type of crude that would be preferable for use in making hydrogenated oils, Dr. Haslam replied that it is a question of economics. If one starts with a base stock that is extremely deficient in hydrogen, he said, it is necessary to add proportionately more hydrogen; therefore it is economical to start as near as possible to the desired goal, although satisfactory results can be achieved with a large variety of stock.

A. A. Lane, of Gulf Production and Pipe Line Co. Research Laboratories, voiced his opinion that the tests of Dr. Haslam and Mr. Bauer, as shown in the paper, would not warrant the statement that the hydrogenated lubricant is thereby proved superior to any other lubricant now on the market. Dr. Haslam agreed that so sweeping a generalization could be safely made only after every product had been tested. The best that can be done, he said, is to pick out four or five products which are believed to be representative of the best in the market and test the hydrogenated product against them, after which all that can be said is that that product is better than the others tested.

At this point, T. A. Boyd, of the General Motors Corp., explained the meaning of the term, "octane number," calling attention to the desirability of making generally known this means of rating fuels with respect to antiknock quality.

W. H. Graves, of the Packard Motor Car Co., asked whether it would be possible, by carrying the hydrogenation process further, to get a flatter viscosity-curve than was indicated in the paper, and Dr. Haslam replied that he had obtained somewhat flatter curves.

Chairman Mougey inquired if the products discussed by Dr. Haslam are still in the experimental stage or are near commercial production, and Dr. Haslam stated that they are near commercial production and probably will be on the market in the spring or summer.

Need for Classification Explained

In passing to the next topic, Chairman Mougey stated that automotive engineers have for many years been unable to recommend transmission and rear-axle lubricants to the public. Many instruction books have contained warnings against the lubricants ordinarily known as fluid greases, those containing a small amount of soap. The reason for this warning, he explained, is not because of any lack of merit on the part of such lubricants, but is simply because the automotive engineers had not known how to classi-

fy these lubricants and discuss them; therefore they felt it best to exclude them all. To remedy such a condition, he continued, the Lubricants Division of the Society's Standards Committee attacked the problem of getting a system of classification whereby the fluid greases as well as the oils could be recommended by the automobile engineers. Stating that work done at the Sinclair Refining Co.'s laboratories has been of great assistance in this connection, Chairman Mougey then introduced C. M. Larson, of that company, who presented his paper entitled, Classifying Transmission and Rear-Axle Lubricants.

In his paper, which is scheduled for publication in an early issue of THE JOURNAL, Mr. Larson discussed the fact that transmission and rear-axle lubricants frequently have small quantities of soap or other material added to decrease the tendency of the lubricant to leak from the housings. Although these additions may increase the apparent viscosity of the oil, they may have little or no effect on the load-carrying properties at high temperatures or the tendency of the lubricant to channel or to make gearshifting harder at low temperatures than with the straight oil.

On account of the many different conditions under which transmission and rear-axle lubricants are used and because of the many different methods of manufacture, no one detailed specification is applicable as an indication of the performance characteristics of a lubricant, according to Mr. Larson. Therefore, he states, consumers must necessarily depend upon the individual oil companies to produce a quality lubricant, using for their guidance a viscosity, consistency and film-strength classification to be determined upon and subsequently published in the car manufacturers' instruction books.

Pressure Viscosity as a Test Means

Replying to a question propounded by W. H. Graves, of the Packard Motor Car Co., Chairman Mougey explained that pressure viscosity presents a satisfactory means for determining the viscosity of both oils and fluid greases, provided that the latter do not contain too much soap. If, however, a large amount of soap is present in the fluid grease, there would not be enough pressure to give true viscosity-values. In such cases, he pointed out, it is necessary to use the viscosity of the separated mineral oil in classifying lubricants, rather than the pressure viscosity of the lubricants.

Robert E. Wilkin, of the Standard Oil Co. of Indiana, told about some of the initial work on pressure viscosity, which had been referred to by Mr. Larson in his preliminary remarks. In this connection Mr. Wilkin discussed some tests that were run on a variety of oils and semi-fluid greases in which the viscosity of the oils varied considerably and the temperature of the shift was not necessarily the same in all cases. Three different types of transmission were employed, one being the synchro-mesh, one the internal-gear type used in the four-speed transmission and the third the conventional three-speed transmission. The results of this work showed that, if the shifting effort were plotted against the viscosity of the oil at the temperaure of the shift, a straight line would be plotted in each case. In other words, regardless of the viscosity of the oil, if the temperatures were such that the viscosity at all tests was the same, the shifting effort would be the same. The presence of soap, or the fact that the lubricant was below its cold-test, did not affect the effort required for gearshifting.

J. R. MacGregor, of the Standard Oil Co. of California, spoke approvingly of the timeliness of a paper on this topic, on account of recent developments in transmissions and rear axles. He also spoke of the matter of caring for partly worn-out equipment, and in this connection discussed the applicability of the viscidometer described in Mr. Larson's paper.

Effect of Rubbing Speed

A very interesting point brought out in the discussion was with regard to the effect of rubbing speed. Chairman Mougey stated that the tests were made more severe by running them at 25 r.p.m. rather than 100 r.p.m.; in other words, lubricants that will pass at 100 r.p.m. will in some cases fail badly at the lower speed. He offered as a possible explanation that a higher temperature is developed at the higher speed and that this causes a chemical action between the lubricant and the pin that is not produced at lower temperatures. Adding a few words to this matter of slow speeds, Mr. Larson stated that, in these tests, more complete seizure and rupture of the pins resulted from the use of a 5-hp. motor than from the use of a 25-hp. motor.

Each of the three papers presented at this session evoked a certain amount of controversy that was carried on in lively but amicable fashion, and the opinion was expressed by the Chairman in his concluding remarks that the engineers who made up the audience had learned much during the session that they had not been able to absorb in so short a time, and that a more leisurely study of the preprints, in the light of the remarks made at the session, would prove to be a profitable pursuit.

CHIEF FIGURES AT THE FUELS AND LUBRICANTS SESSION

(Top) W. C. Bauer and R. T. Haslam, of the Standard Oil Development Co., Co-Authors of a Paper on Petroleum Hydrogenation

(Bottom) W. R. Ramsaur, of the Harrison Radiator Corp., Who Presented a Paper on Oil-Coolers and Oil-Cooling; C. M. Larson, of the Sinclair Refining Co., Who Gave a Paper on Classifying Transmission and Rear-Axle Lubricants; H. C. Mougey, of the General Motors Corp. Research Laboratories, Chairman

Safety Aspects of Car Construction

Commissioner Stoeckel Wins Approval by His Presentation of Motor-Vehicle Administrator's Problems

IF ALL STATE motor-vehicle commissioners were as open-minded and willing to cooperate as Robbins B. Stoeckel, the Commissioner of Motor-Vehicles of Connecticut, showed himself to be by the paper he presented at the final session of the meeting on Friday afternoon, the manufacturers of motor-vehicles would find it easy to arrive at reasonable adjustments of their differences in views, and the users would find life on the highways threatened with fewer annoyances. Such, at least, seemed to be the sentiment of those who listened and those who discussed the paper.

Dr. Miller McClintock, of the Albert Russell Erskine Bureau for Street Traffic Research, presided and in his opening remarks said that the accident situation has come to be one of our major social and economic problems. Until remedies are found, he believes it is impossible to develop the automobile to its fullest efficiency, economy and utility. Those who know the conditions, however, believe that specific remedies are to be found primarily in better highways, better vehicles and better drivers. The better vehicles, he said, are a subject of direct importance to the automotive engineers and the industry and of concern to the men responsible for administering the motor-vehicle laws.

Laws Becoming More General

Commissioner Stoeckel pointed out that the function of the motor-vehicle commissioners is to safeguard all users of the highways. This duty has been wished upon them because of the conditions of traffic congestion and the development of motor-vehicles that have arisen. Regarding laws, he said that the trend is for them to become more simple, more inclusive and so general in language and application that reasonable compliance with them can be insisted upon. They tend to fix the responsibility upon the individual and toward measuring his performance by reason.

The authorities in Connecticut realize that the laws have been too particularly drawn to fit all cases and cannot be adapted. As an example, he cited the law in many States specifying two independent brake systems that are not connected with each other, saying that, through engineering development, many cars do not now conform with this clause of the laws. It would be much better, he said, if the laws merely required that vehicles be provided with brakes that are adequate for safety. So far as Connecticut is concerned, it may be expected that a law will be offered that will be broad in language and application and that the vehicle manufacturers will be relied upon to make good brakes. A standard of maintenance will have to be reached, however, to which the brakes will have to measure up in usage.

Some Hazard Factors Being Studied

The State is just beginning a research into the causes of fire in motor-vehicles and hopes to know something about them in three or four years. Car manufacturers might study the subject and, so far as possible, make provision to reduce the fire hazard. Insurance statistics indicate that fires do not arise from any proximate cause upon which a finger can be put, but usually from a contributory cause, such as collision, with spark ignition of the gasoline. Some differentiation, suggested Mr. Stoeckel, might perhaps be made, in compiling statistics, between cars in which the wiring is armored and those in which it is not. Placing of the fuel tank is a factor that is going to be investigated in connection with its relation to fire.

Another question that is coming up is that of safety glass. Most administrators know that personal inquiry in a great proportion of accidents results from broken glass, and public sentiment is growing so fast that already there is a tendency for legislators to insist that all cars should be provided with safety glass. This has not yet made itself manifest in legislation but it is in the future.

No State administrator can yet say much about free-wheeling, said Commissioner Stoeckel; he looks upon it much as he does on any new development that will force him to reeducate his public. The Connecticut Commissioner's office feels obliged to tell operators in the State how free-wheeling will affect their operation, the advantages it gives and how the administrator expects the drivers to perform. About 85 out of 100 persons probably will use free-wheeling correctly, which is about the proportion that use any device correctly. It is against the other 15 per cent that the authorities have to

CHAIRMAN, SPEAKER AND DISCUSSERS AT THE GENERAL SESSION

(Top) Dr. Miller McClintock, of the Erskine Bureau for Street Traffic Research, Chairman; Robbins B. Stoeckel, Commissioner of Motor Vehicles for Connecticut, Who Addressed the Meeting on Safety in Automobiles; A. K. Brumbaugh, of the White Motor Co., a Discusser

(Bottom) J. H. Hunt, of the General Motors Corp.; D. Beecroft, of the Bendix Aviation Corp.; and R. E. Carlson, of the Westinghouse Lamp Co., Discussers

fight for safety, who must be watched, educated and disciplined.

Laws regarding lighting were referred to as another example of overdoing legislation. Commissioner Stoeckel thinks we should be better off if the lamp manufacturers were let alone and merely told in general terms how the authorities want the lamps to perform. In this the lamp and car manufacturers undoubtedly agree with him. Conditions vary so much in different parts of the Country that requirements which may suit one State do not fit another State. Connecticut highways are rolling and winding, while in the North Central and Middle West States they are straight and level. An investigation just made in Connecticut as to the use of two-filament lamps has shown that glare is more of an annoyance than a hazard, because drivers slow down and are more cautious when danger is obvious and bad lighting is to that extent a safeguard against night accidents. Statistics reveal comparatively few accidents that can be traced to glaring lights.

The restrictive law on candlepower is to be corrected in Connecticut, where a bill is already in the legislature to make 32-cp. lamps legal. Commissioner Stoeckel suggested that lamp manufacturers might consider the probable length of life of a car and build their lamps to have a corresponding life, and also make them easy to focus and to keep in focus.

Old Cars Not Specially Dangerous

With reference to old cars on the highways, the speaker took issue with a recent statement attributed to President Henry, of the American Automobile Association, that 8,000,000 old cars should be removed from the highways because they are unsafe. His experience has been that old cars are not necessarily unsafe; on the contrary, the cars that have been found most imperfect are those that the owners regard as still new and on which they neglect to adjust the brakes and otherwise keep in good order. The State is trying hard, however, to get unsafe old cars off the roads and has a junkyard law that contains an unintentional joker that prohibits a junkyard man from selling a used car without reporting its condition to the Commissioner of Motor Vehicles.

Noise is a subject that is receiving more attention in the East, and the Connecticut legislature is being besought to remedy the noise of vehicles. Any such legislation is most likely to be directed at the horn.

To sum up the whole subject, Mr. Stoeckel remarked that the safety factors mentioned should be continuously in the foreground of every manufacturer's program and that, as the result of an educational campaign by the States that is now beginning, every man who buys a car that is unsafe in any quality whatsoever will do so with a knowledge of its unsafe features.

Discussers Compliment the Speaker

Members who offered discussion on the topic congratulated the Society on having the Commissioner as a speaker at the meeting and complimented him upon his fair and broad-minded presentation of his problems. David Beecroft referred to the detailed statistics of accidents contained in the Commissioner's annual reports and suggested that the automotive engineers have not made sufficient study of them. One figure that he said always remained in his mind is that 44 per cent of the accidents occur at intersections, and he wondered what were the reasons for them.

Chairman McClintock remarked that the Commissioner had offered to send his last annual digest to all who would leave their names with him after the meeting.

J. H. Hunt, of the General Motors Corp., congratulated the Meetings Committee for arranging to have such a fair presentation made and having engineers told of their responsibility. The manufacturers could promptly correct unsafe construction of their vehicles, he said, if the State motor-vehicle commissioners could organize their offices so that they could quickly give the makers information as to how new devices work out in operation. Because of the competitive situation, he thinks, however, that freedom in talking over proposed new developments with the commissioners may not be feasible.

The present solution of the lighting problem, stated R. E. Carlson, of the Westinghouse Lamp Co., is the dual-beam lamp, which, if properly used, gives adequate lighting for safe driving at high speed and gives the driver a means for minimizing glare. The aiming of the upper beam might profitably be raised if drivers could be relied upon to use it with common sense and use the lower beam when occasion calls for it. He inquired if Commissioner Stoeckel favors compulsory inspection of headlamps prior to registration of the car.

To this question the Commissioner replied that he has a thorough belief in the future courtesy of the driver, in connection with everything about driving his car, but that if the upper beam were raised there might be a tendency to unsafe speed in territory such as that in Connecticut and Massachusetts. Probably in another year a course of inspection of cars awaiting registration will be initiated. He criticized the tests made by the automobile clubs, saying that in his opinion it is bad practice to conduct them on the basis of perfection, which makes it look as if a large percentage of cars in a State were in bad condition. He thinks the test should be only for safety in road service.

Slow Vehicles a Menace

A. K. Brumbaugh, of the White Motor Co., sought to obtain an expression of opinion as to whether public interest will be served by the operation of trucks and motorcoaches having still more powerful engines than at present. To this Mr. Stoeckel responded that the speed problem is becoming one of average speed and that he is expecting that in Connecticut the time is coming when the State can have one-way traffic on roads between the large cities, and then the trucks and coaches will be expected to keep up with the procession. It is to the advantage of the public to have more speed, whether by means of larger engines or in any way it can be obtained; the slow-speed driver, he said, is more of a problem than the fast driver. He has taken many licenses away from slow drivers on the ground that they are inconsiderate of other users of the highway, and made them beg for their return.

However, the authorities do enforce the State law regarding gross weight, which is limited to 28,000 lb., especially in the spring, and if larger engines are installed they will reduce the payload. Loads are also restricted to the maker's capacity rating of the truck, on the theory that the vehicle is built for the safe control of that load. The unit length is held to 40 ft., and the State has a minimum-speed limit of 12 m.p.h. to prevent putting a body on a tractor and driving on the road at 8 m.p.h. Some interstate motorcoaches "go thundering through the State, the owners taking advantage of the fact that the State has no jurisdiction over them except under police regulations. But it is hoped that Congress will give the States and the Interstate Commerce Commission control over them."

Committee Meetings on Aircraft Lighting Specifications

THE Subdivision Committee on Airplane Lighting that was appointed by the Aircraft Division of the Standards Committee met on Thursday afternoon to review its work and determine its future course. Over a year ago experimental equipment had been furnished to several commercial aircraft companies and the U. S. Army Air Corps for the purpose of determining by experimental flights and landings what each considered to be desirable landing illumination with various types of light distribution and under various landing conditions.

A review of this program indicated that practically no results of value had been obtained and that the very nature of the problem itself makes it impossible at the present stage in the development of aircraft lighting to secure definite and uniform data. It was felt that improvements will be made in the natural course of experience in flying

that may eventually make it possible for the Committee to prepare definite specifications, and accordingly the Committee decided to discontinue its work in this direction until some future time.

It was felt, however, that the Committee should not be discharged, and accordingly it was decided to request the Aircraft Division of the Standards Committee that it be continued as an advisory committee to aircraft and aircraft-equipment manufacturers, the several branches of Government air service, and to aircraft operators for the consideration of such problems as may come up from time to time. In continuing its activities in this way the Committee does not expect to recommend specifications for adoption by the Society except where it may prove feasible and desirable to do so in the opinion of those with whom the Committee may consult as well as the members of the Committee itself.

One problem in particular was discussed, on which it was felt that the Committee could be helpful to the aircraft industry along the lines indicated. This subject was suitable and safe wiring and wiring systems, including conduit, junction boxes, fittings and terminals on airplanes. The Society will prepare a questionnaire on the basis of data and questions that will be submitted by Lieut. D. L. Brunner, of the U. S. Army Air Corps, who is a member of the Committee, and send it to those concerned with the installation of airplane electrical equipment other than for ignition. When sufficient replies have been received they will be referred to the Committee, which it was felt may then be able to make definite recommendations that will be of great value to the aircraft industry and possibly establish a definite and satisfactory guide for the manufacturers of this class of equipment.

This Committee in continuing its activities will be known as the Aircraft Electrical Equipment Subdivision of the Aircraft Division of the Standards Committee.

1931 Transportation Committee

Chairman F. K. Glynn Succeeds Chairman F. C. Horner of the 1930 Committee

REPORTS of the Subcommittees of the 1930 Transportation and Maintenance Activity Committee were presented at the joint Meeting of this Committee with the 1931 Committee. The purpose of this Meeting was to review in a general way the work of the 1930 Committee and to discuss the program for the 1931 Committee. Chairman F. C. Horner of the 1930 Committee presided first and, during this time, the various 1930 Subcommittee reports were presented.

For the Meetings Subcommittee it was stated that no report was necessary, because all present were familiar with the situation and nothing as yet had been done with reference to the 1931 Summer Meeting. For the Membership Subcommittee it was stated that the acquisition of new members without putting forth any canvassing campaign have been gratifying, but that inasmuch as the prospect list is not yet exhausted no public campaign should be instituted.

For the Motorcoach Code Subcommittee, in view of the fact that the legislatures of 44 States are in session during 1931, it was felt best to let the subject stand as it is at present, at least until it can be determined what limitations will be imposed by all the States. It was agreed that further recommendations, if made at this time, might be entirely out of line. Meanwhile, it was mentioned that the National Automobile Chamber of Commerce is watching the situation closely.

With regard to the Subcommittees on the subjects of a Uniform Method of Cost Comparison and a suitable Chassis Record Form, it was felt that sufficient work had been done so that, following an analysis of the replies to outlines of this work which have been sent out for criticism, these subjects are sufficiently developed to present them to the Standards Committee for consideration. It is hoped that at a later date these findings may be completed, approved, and published in the S.A.E. Handbook.

Chairman Horner remarked that the work of the Subcommittee on Motor-Truck Standardization probably would need to be continued as a Subcommittee Activity for the coming year, because work by its members is still being carried on. It was stated that the work is on the verge of accomplishment, but that further work needs to be done. The suggestion was made that a Subcommittee recently authorized by the National Automobile Chamber of Commerce might be included to cooperate with the Society's Subcommittee, and that this joint Committee, if formed, would be a step toward actual acceleration of the work.

A. S. McArthur, Chairman of the Subcommitte in Operation, presented a progress report in which it was stated that 15 subjects of those transmitted to it by the 1929 Subcommittee were desirable for study, and these subjects were enumerated. For the Subcommittee on Maintenance, Chairman J. F. Winchester remarked that a Meeting was held early in the Spring of 1930, but that it had been practically impossible to get a suitable personnel to prosecute the work and that relatively no progress had been made.

After appropriate remarks by Chairman Horner of the 1930 Committee as to the work of the last year, he relinquished the Chairmanhip to F. K. Glynn, the incoming Chairman for the 1931 Committee. Chairman Glynn remarked that the accomplishments of the Committee for the year 1930 afforded an example which will be very difficult for the 1931 Committee to surpass. He then stated that the Committee for 1931 consists of about 32 members and that A. S. McArthur of the Toronto Transportation Commission is Vice-Chairman of the Committee.

After making this announcement, Chairman Glynn said that Adrian Hughes, Jr., is to continue as Chairman of the Eastern and Central portion of the Country on the Meetings Committee, and that associated with him are Messrs. Lyman, Coleman and Preble. He specified as their first duty the securing of details for the Summer Meeting session on Transportation the second duty being the laying out of a program for the National Transportation Meeting.

After numerous possible locations for this Meeting had been mentioned and commented upon, it was moved that the Meetings Committee arrange for holding the Meeting in Washington, D. C., as it was the consensus of opinion that both the Baltimore Section and the Washington Section would cooperate most heartily toward making this meeting a complete success.

With regard to the possibility of holding a National Transportation Meeting on the Pacific Coast it was announced that a Subcommittee to consider this matter had been appointed, with E. C. Wood of San Francisco as Chairman. It was felt that this particular project would need to be carried along and discussed with the Pacific Coast members to make certain that the time is ripe to initiate such a Meeting.

E. C. Wood discussed the possibility of holding a Pacific Coast Transportation Meeting and said that both the Southern and Northern California Section believe the time is suitable for a National Transportation Meeting. He believes, however, that the Portland and the Northwest Sections will need more time before conditions are favorable in that regard as concerning their respective territories.

Regarding the Membership Committee personnel, it was stated that H. V. Middleworth is Chairman of the Subcommittee. The National Membership

Committee's idea is that membership increase will not follow a normal path until economic conditions are on the up-grade. Further, that then some active membership-campaign work will be in order.

Cost Finding and Chassis Records

Chairman Glynn said that the subject of a Uniform Cost-Comparison record-form development will continue along the lines already mentioned and that the Subcommittee will stand until all of the requirements are met as heretofore specified, so that the form may be simplified, referred to the Standards Committee and later included in the S.A.E. HANDBOOK if a decision is reached to that effect. The 1931 Subcommittee has for its Chairman J. F. Winchester, and as members T. L. Preble, A. J. Scaife and H. V. Middleworth.

With regard to the proposed Chassis Record Form, Chairman Glynn said that apparently it was the opinion that the Subcommittee should meet again with a view toward simplification of the form and carry through the necessary routine to have this form included in the S.A.E. HANDBOOK.

With reference to Motor-Truck Standardization, Chairman Glynn stated that the original Subcommittee of the Transportation Activity is to be continued. J. F. Winchester is Chairman, T. L. Preble and Mr. Glynn being the members. "This work no doubt will carry through the entire year," he said, "and it is my hope that real progress may be made so that when we meet later in the year we can announce that the objective is either accomplished or in sight."

The Motorcoach Code Subcommittee is continued as constituted in 1930, as stated by Chairman Glynn.

Two New Subcommittees Formed

Chairman Glynn said that two new Subcommittees are proposed for the Transportation and Maintenance Activity. He suggested that study be made of the equipment and operation of fleet repair-shops as compared with the equipment and operation of manufacturers' and commercial repair-shops, in order to obtain the best data for each system and use it for the benefit of everyone.

For example, Chairman Glynn remarked, it is entirely practicable and similarly worth while to obtain an actual comparison for the maintenance equipment as handled in a fleet shop and as handled in the manufacturers' or in the commercial repair-shops, such as the extent to which parts replacements are carried on the shelves of the storeroom, the extent to which unit assemblies are carried and the like. He gave a concrete example considering 1000 vehicles operating in a given city. He said further that J. M. Orr, of Pittsburgh, had been selected as Chairman of this Committee.

The second new Committee was discussed pro and con with regard to its title. Chairman Glynn read a letter from T. L. Preble favoring an effort to make executives appreciate more fully the importance of the men in their companies, who are directly responsible for the operation and maintenance of the vehicles.

The Subcommittee as suggested consisted of Mr. Preble as Chairman, and Messrs. Horner, Newton, Palmer, Lee and Lowe as members. As a matter of comment, R. E. Plimpton said that he believes that this project will be well worth while. After various other suggestions had been made, it was stated by Chairman Glynn that the intention is to gain recognition which rightly belongs to motor-vehicle operators, that is, the man responsible for the operation of a motor-vehicle fleet as influenced by the preceding discussion. Chairman Glynn agreed that the title of the work to be done by this Subcommittee is best stated as "Problems Confronting the Transportation Engineer."

It was stated that the National Electric Light Association has already recently formed a Motor Transport Committee. In view of this action, Messrs. Horner and Glynn sent a telegram to E. W. Jahn, who is the Chairman of this aforesaid Committee, as follows:

Mr. E. W. Jahn, Chairman, Motor Transportation Committee of the National Electric Light Association, Baltimore, Md.

Heartiest congratulations on formation your Motor Transportation Committee. Hasten to extend to you our earnest desire to cooperate with you and all members of your Committee in promoting the science of motor transportation and its application to problems affecting your industry. Would be pleased to meet with you at an early date to discuss details of how our respective committees may best cooperate. Wishing your every success,

(*Signed*) Horner and Glynn, Chairmen 1930 and 1931 S.A.E. Transportation and Maintenance Committees.

In conclusion Chairman Glynn suggested White Sulphur Springs, W. Va., as the place for the next Meeting of the Transportation and Maintenance Activity Committee. A Transportation Session is scheduled for the Semi-Annual Meeting of the Society, which is to be held there, June 15 to 19, 1931.

Truck and Motorcoach Committee

Chairman L. R. Buckendale Succeeds Chairman A. J. Scaife of the 1930 Committee

THE joint meeting of the 1930 and the 1931 Motor-Truck and Motorcoach Activity Committees was held Tuesday morning, Jan. 20. Reports of the Subcommittees of the 1930 Committee, closing the year's work, were received. For the Meetings Committee a brief report was rendered which reviewed the Transportation sessions at the National meetings of the Society and the National Transportation meeting held during the year. It was reported for the Motorcoach-Code Committee that a joint meeting had been held with the Subcommittee of the Transportation and Maintenance Activity Committee during the early part of 1930, at which a number of recommendations were formulated and submitted to the Motor Vehicle Conference Committee for consideration in the future editions of the Uniform Motorcoach Code distributed by the Motor Vehicle Conference Committee. There was considerable discussion of the Conference Committee's activities in connection with eventually bringing about uniformity in the regulations governing motorcoach over-all dimensions in all the States. It was not felt that any further immediate action can be taken by this Subcommittee until the Motor Vehicle Conference Committee considers further revisions of the present Code, which does not seem probable at this time because too many of the State legislatures will be in session during this year.

In reporting on the activities of the Motor-Truck Standardization Committee it was stated that, at the time of the National meeting of the American Petroleum Institute at Chicago in November, 1930, the standardization of motor-trucks from back of the cab to the center line of the rear axle, and to some extent frame width, had been considered carefully. Decisive action by the National Automobile Chamber of Commerce was postponed, pending further joint consideration of these subjects with the Society.

A brief report was also given of the joint meeting of the Committees of the Motorcoach and Motor-Truck Activity Committee, the Transportation and Maintenance Activity Committee, the Motorcoach and Motor-Truck Division of the S.A.E. Standards Committee and the N. A. C. C. Truck Standards Committee in New York early in January, 1931, at which it was decided to request a subdivision of the Motorcoach and Motor-Truck Division of the S.A.E. Standards Committee to give further study in cooperation with the motor-

truck manufacturers and various classes of motor-vehicle operators, to the standardization of a definite series of back-of-cab-to-rear-axle dimensions based on data covering current models of the motor-truck manufacturers.

With appropriate remarks Chairman A. J. Scaife turned the meeting over to L. R. Buckendale, the Chairman of the 1931 Motorcoach and Motor-Truck Activity Committee, who announced B. B. Bachman as the Vice-Chairman of the Committee and Chairman of the Meetings Committee; C. F. Magoffin, Chairman of the Membership Committee; A. J. Scaife, Chairman of the Motorcoach-Code Committee and C. A. Pierce, Chairman of the Motor-Truck Standardization Committee for 1931.

Mr. Buckendale then stated that he felt that the Committee could serve most effectively in an advisory capacity and to determine policies in connection with the furtherance of the motorcoach and motor-truck activities of the Society during 1931, and that it was with this thought in mind that the Committee had been constituted as it is. He also indicated that he would like the Chairmen and members of the several Committees to determine very largely their own programs for the year.

In connection with the meetings program of the Activity it was decided to report to the National Meetings Committee that the Activity Committee will plan for one motorcoach and motor-truck session at the Summer Meeting of the Society at White Sulphur Springs, W. Va., in June, 1931, and to arrange with the Transportation and Maintenance Activity for at least one motorcoach and motor-truck session at the National Transportation Meeting next fall, or possibly to have two sessions in one day of that meeting if it is planned as a three or four day Transportation meeting.

General Plan Outlined

In outlining the general program for the Subcommittees during the year, Mr. Buckendale indicated that he felt this should include mainly consideration of important topics for papers, the nature of which might relate to engineering problems; commercial problems affecting the manufacturers; or to the questions of operation that affect the design and performance of the vehicles. In discussing the program, it was indicated that the nature of such problems has changed with the development from relatively smaller and slower-speed vehicles to larger and more powerful ones, and that consequent problems, such as State restrictions and regulations on their operation, has affected their design. One of the main objectives of the Committee should be to establish a fully cooperative relationship between the manufacturers and the operators to work out their mutual problems more effectively.

Another suggestion was to secure greater standardization of trailer hitches—especially the fifth-wheel and semi - automatic trailer - connections—reference being made to the discussion and action taken on this subject at the National Transportation Meeting held in Pittsburgh, Oct. 22 to 24, 1930.

New Topics Considered

Among the new topics discussed was the need for establishing a uniform method of rating the capacity of motor-trucks and a review of many of the disadvantages and troubles resulting from the lack of such a standardized rating. There was also considerable discussion of the possibility of agreeing upon a standard method of guarantee on new motor-trucks to replace the 90-day guarantee, which, under present conditions, is working many hardships on the manufacturer. It was felt that this would be a difficult matter, but that it might be possible for the Committee to arrange for a paper dealing with the subject in a broad and effective manner.

It was finally arranged with M. L. Pulcher that he will prepare a paper dealing with motor-truck ratings and guarantees for presentation at the motorcoach and motor-truck session of the Summer Meeting of the Society in June, and that each member of the Activity Committee will send to the Society his suggestions in connection with further study of this subject for Mr. Pulcher's use in preparing his paper.

It was also understood that the members of the Committee will be canvassed for their suggestions as to topics for papers to be presented at the motorcoach and motor-truck session of the National Transportation Meeting next fall. Those present felt that the next meeting of the entire Activity Committee should be scheduled at the time of the Summer Meeting of the Society at White Sulphur Springs, W. Va.

There being no further business, the meeting adjourned.

Meetings Committee Outlines Plans

A MEETING of the Meetings Committee was held on Friday morning, Jan. 23, at the Book-Cadillac Hotel, Detroit. Breakfast was served at 8:30, and members of both the outgoing and incoming Committees were present to take part in the lively discussion of various meetings matters that ensued.

Plans for the year were outlined in a general way. A major part of the deliberations was concerned with the program for the Summer Meeting, which is to be staged at White Sulphur Springs, W. Va., June 15 to 19. The Professional Activities of the Society presented requests to the Meetings

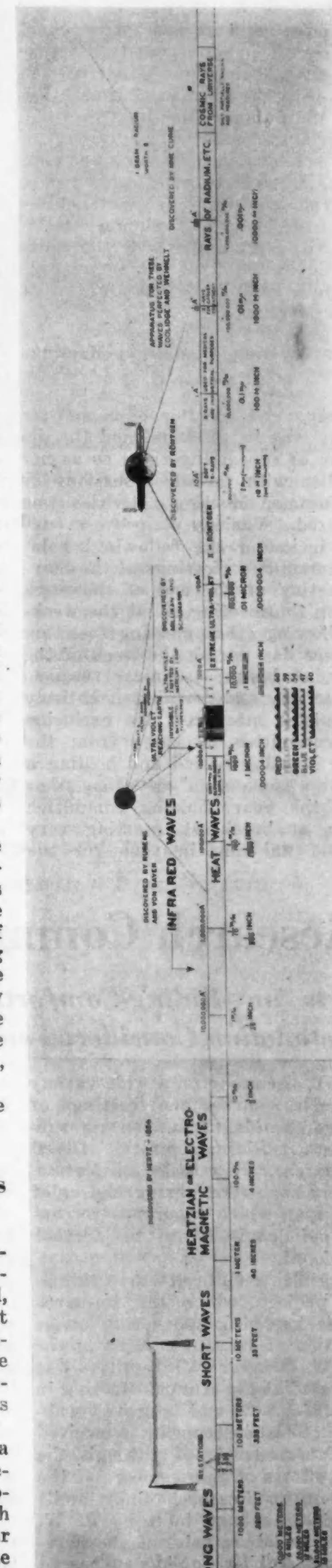


CHART OF SCALE OF RAYS

Exhibited at Body Session by H. L. Towle, Who Said the Rays Are All the Same Except for Length (See p. 129)

Committee to be allowed to sponsor one or more sessions each on the Summer Meeting program, and these requests, after being considered in connection with the amount of time available at the Summer Meeting, were tentatively approved. The practice of holding sessions each morning and each evening, leaving each afternoon free for sports activities, was mentioned as having worked well at Summer Meetings in the past, and it was the sense of the Committee that the same practice should be followed at this year's Summer Meeting.

Summer Meeting Committee-Meetings Problem

The perennial question of committee meetings was brought up, and the desirability of scheduling them so as not to conflict with technical sessions or other Summer Meeting activities was emphasized. Various plans were suggested, including the following: holding all committee meetings at the Summer Meeting at the end of the week preceding the meeting, or at the week-end following the meeting; setting aside some day during the week of the meeting, excluding technical sessions from that day and devoting it entirely to committee meetings; the exclusion of all committee meetings from the Summer Meeting period and holding a "committee convention" at some other time in the year; holding committee meetings at breakfast, starting very early and finishing in time for the committee members to attend whatever technical session or sessions are scheduled for the morning period; and limiting the number of committee meetings that may be held during the Summer Meeting, allowing Administrative Committees to meet but insisting that Technical and Professional Activities Committees hold their meetings at other times.

After much discussion, in which the advantages and disadvantages of each suggestion were considered, the suggestion was offered that the Chairman appoint a small subcommitee, consisting of himself and two other Meetings Committee members, to work with the home office in an endeavor to formulate a plan for the satisfactory scheduling of committee meetings, this plan to be submitted by mail to the members of the Meetings Committee. In accordance with this suggestion, it was moved and seconded that a subcommittee be appointed for the purpose mentioned; and, upon the motion being unanimously carried, Chairman Shidle appointed B. B. Bachman as chairman of the subcommittee, with F. C. Horner as the other member.

Those who attended the meeting, in addition to Chairman Norman G. Shidle, were the following committee members: V. G. Apple, B. B. Bachman, C. S. Bruce, A. K. Brumbaugh, C. B. Harper, F. C. Horner, W. S. James, P. J. Kent, W. C. Keys, C. H. Kindl, Arthur Nutt, A. J. Poole and J. P. Stewart; and, from the staff, R. S. Burnett, U. Delchamps and C. B. Veal.

Research Committee Meetings

Reports on Riding-Comfort, Fuels, Lubrication and Detonation Considered and More Work Planned

LIVELY discussion on a wide variety of topics marked the meetings of the Research Committee and its subcommittees. Riding-comfort, Diesel fuel research, vapor lock, lubrication, and detonation were among the chief subjects upon which reports were considered and definite plans for further work laid out.

A tangible result of the riding-comfort project, which the Research Committee has been sponsoring under the direction of Dr. F. A. Moss at the George Washington University, was demonstrated at the Annual Meeting in the form of a new and improved wabblemeter. This instrument, conceived by Dr. Moss, developed through the combined efforts of the members of the Riding-Comfort Research Subcommittee and designed and built by R. W. Brown in the laboratories of the Firestone Tire & Rubber Co., has surpassed all expectations in providing an accurate, dependable and valuable indication of fatigue. It measures the most fundamental and primitive accomplishment of mankind—the ability to maintain balance standing upright—and has brought to light not only a definite correlation between bodily steadiness and fatigue, but has shown many other interesting correlations which are discussed fully in Dr. Moss's paper reported elsewhere in this issue.

A wide industrial application of the wabblemeter has been predicted and orders for ten of the instruments have already been placed with Dr. Moss. The Committee has expressed willingness to arrange for the construction of additional instruments for those interested in obtaining them in order to widen the scope of this cooperative effort to solve the comfort enigma.

Another phase of the riding-comfort project, going forward at Purdue University, has resulted in the development of a steadiness meter described by Dr. Ammon Swope in his report at the General Development Session which is covered in detail elsewhere in this issue; while a third portion of the project, still in the preliminary stages, is expected to provide adequate data on the motions of automobiles to round out the correlation between car motions, bodily effects and subjective reactions as expressed by the passengers.

Subcommittee on Shock-Absorbers

While not a part of the riding-comfort project, closely related to it is the testing of shock-absorbers. As a result of a discussion concerning current practice in this field, the Committee authorized the organization of a subcommittee, with Tore Franzen as Chairman, on methods of testing shock absorbers. This committee has been charged with the task of developing, experimentally if necessary, a uniform method or methods of test.

Fuels occupied a considerable portion of the Research Committee reports and discussion.

To Invite A.S.M.E. Cooperation

A research program on the fundamental characteristics of Diesel fuels had previously been approved by the Research Committee at its meeting at French Lick Springs last May but has been held in abeyance awaiting the procurement of adequate financial support.

Discussion of the problem in a joint meeting of the Fuels Research Subcommittee and the Diesel Engine Activity Committee brought to light a parallel and partly overlapping interest in this work on the part of the A.S.M.E. Diesel-Fuels Research Committee, whereupon the Research Committee, on the recommendation of the Fuels Subcommittee, agreed to extend to the A.S.M.E. group an invitation to cooperate with the S.A.E. in carrying out this Diesel-fuel research program.

It was also generally agreed by those present at the Research Committee meeting that it would be valuable to extend to Diesel fuels the vapor-lock research work being conducted at the Bureau of Standards under the guidance of the Cooperative Fuel-Research Steering Committee.

Will Undertake Research on Sulphur

On the question of gum and sulphur content of gasoline, the Committee favored consideration of the problem of gum by the Cooperative Fuel-Research Steering Committtee and took definite action designating research on sulphur as a project which should be handled by the Steering Committee.

Aid Sought on Lubricants Study

As a result of general discussion on a proposed program of lubricants and lubrication research, the Chairman was authorized to appoint a subcommittee to confer with persons who are outside

the membership of the Research Committee but who are undoubtedly vitally interested in this undertaking and to contact with the American Petroleum Institute representatives on the Cooperative Fuel-Research Steering Committee with a view toward securing their technical and financial aid in carrying out this program.

Knock-Test Engine Approved

The Detonation Subcommittee of the Cooperative Fuel-Research Steering Committee occupied a premier position in the Annual Meeting program, not only as sponsor for the most spectacular and best attended session but as host to Messrs. R. Stansfield, C. H. Barton and C. H. Sprake, co-authors of a contribution to the Detonation Symposium and representatives of the British cooperating committee of the Institute of Petroleum Technologists.

The exhibition of the Cooperative Fuel-Research Steering Committee knock-testing engine with new valve-in-head, integrally cast cylinder and equipped with a specially designed four-float-bowl carbureter, topped the list of noteworthy happenings in the province of detonation.

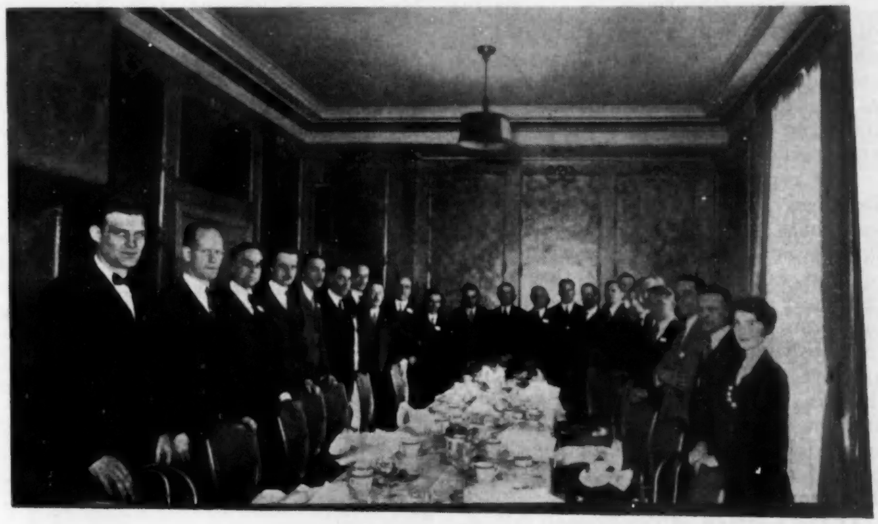
The Detonation Subcommittee, at its meeting on Monday morning, gave a unanimous expression of complete satisfaction and approval of the efforts of the Waukesha Motor Co. on this engine to date and reiterated its intention and expectation of developing through that company a knock-testing unit to be recommended as standard knock-testing equipment. The Committee further pledged the companies represented in its membership to purchase such standard knock-testing units from the Waukesha Motor Co. only, for a period of two years after final approval of the unit. This last clause was agreed upon as a fair guarantee to Mr. Horning and the Waukesha company in view of the large financial investment of that company in the undertaking up to the present time.

The Committee also authorized the contruction of a limited number of hand-made carbureters of the present design to be supplied to the members of the Committee for further trials, with the idea of making the carbureter available to all purchasers of the Horning engine at the earliest possible time.

Test-Procedure Method Approved

Following a lengthy consideration by both the Detonation Subcommittee and the British cooperating group of the best practice at the present time in knock-testing procedure, the Detonation Subcommittee took definite action to the effect that, pending the adoption of a standard method of procedure for the measurement of the antiknock properties of motor fuels, the deliberations of this Subcommittee, including the method proposed by A. L. Beall as modified by the Committee's proceedings, be indicated as a guide to the members of the Subcommittee in the prosecution of its immediate program and be suggested to purchasers of the Horning engine as a method of procedure.

As a sequel of this action, a special committee was appointed to formulate and consolidate this material into a workable method of knock testing, thus making available a tentative procedure in advance of a recommendation for standardization of method.



DETONATION SUBCOMMITTEE MEETING
Luncheon Joint-Meeting of Detonation Subcommittee of the Research Committee and British Delegates from the Institute of Petroleum Technologists

Standards Committee Session

Practically All Reports Approved as Submitted Except for Minor Corrections in a Few Instances

THE REGULAR meeting of the Standards Committee was held on Monday morning, Jan. 19. The Committee members and guests present numbered about 50. Arthur Boor presided as Chairman of the Standards Committee. In all, 32 reports were submitted by 12 Divisions of the Standards Committee, a number of which included new Standards for approval and adoption by the Society.

In addition to the reports of Divisions that were printed in Section 3 of the January, 1931, issue of the S.A.E. JOURNAL, a report was presented by the Electrical Equipment Division on non-metallic conduit for inclusion in the 1931 edition of the S.A.E. HANDBOOK, if approved; but, as a result of discussion, this report was withdrawn for further consideration by this Division.

The Lubricants Division also submitted a supplementary report on transmission and rear-axle-lubricant viscosity-numbers that is the culmination of the revision of the present S.A.E. Standard for transmission lubricants. This revision was begun in June, 1928, as it was then the belief of the Division that the present specification, adopted in February, 1924, does not meet the purpose of such a specification as it is restricted to oils only, to the exclusion of lubricants containing small quantities of soap (fluid greases) and excludes commercial oils with viscosities between 120 to 150 and those above 170 Saybolt sec. at 210 deg. fahr.

A tentative revised specification was formulated by the Division in May, 1930, the circularization of which among oil companies and automotive manufacturers resulted in a revised report that was considered and approved by the Division at a meeting held in New York City on Jan. 10, 1931. The new specification will be published in an early issue of the S.A.E. JOURNAL and will supersede the present S.A.E. Standard on transmission lubricants as printed in the 1930 S.A.E. HANDBOOK.

In the report of the Tire and Rim Division, supplementary tables that had been developed and approved by the Tire and Rim Association, Inc., as agreed upon at the meeting of the Division, Dec. 16, 1930, were also submitted. They show the standard rims on which standard tire-sizes are carried as original equipment on passenger-cars, motor-trucks and motorcoaches.

A few modifications in the nature of corrections in a number of the reports printed in the January, 1931, issue of the S.A.E. JOURNAL were made at the Standards Committee meeting, including the Aircraft Division Report on Extruded Aluminum-Alloy Shapes.

The report of the Ball and Roller Bearings Division on ball bearings, lock nuts and washers, was modified largely in view of the difference of opinion as to whether the threads on the shaft should be 11 or 12 pitch for lock nuts above the No. 14 size. At this meeting the Committee decided to approve the report up to and including the No. 14 size as S.A.E. Standard, and the larger sizes as S.A.E. Recommended Practice, because of the difference of opinion as to the thread pitch that should be specified.

At the meeting of the Council following the Standards Committee meeting, this report was also discussed at length; primarily from the viewpoint of what policy should govern in the consideration and approval of this report. The Council finally decided that the report down to and including No. 14 lock nut should be approved as S.A.E. Recommended Practice and that the No. 15 and larger sizes be omitted from publication in the S.A.E. HANDBOOK, inasmuch as the great majority of automotive applications are represented in the smaller sizes. It was felt, however, that the sizes beyond the No. 14 size might properly be considered by the Sectional Committee on Standardization of Ball Bearings that is sponsored by the Society and the American Society of Mechanical Engineers under the procedure of the American Standards Association for future inclusion in the American Standard for Ball Bearings, which includes the larger sizes of bearings for industrial applications as well as those which have been standardized for many years by the Society for automotive use.

The report of the Screw-Threads Division on round unslotted-head bolts of the automotive type, on p. 20 of Section 3 of the January, 1931, issue of the S.A.E. JOURNAL, was withdrawn in view of the recurrence of uncertainty regarding the patent situation since the report was published.

One of the important phases of the reports that were considered by the Standards Committee is the policy that had been adopted by the Tire and Rim Division in the preparation and presentation of its reports, this policy being to recommend to the Society the adoption of only tire and rim specifications for standard nominal sizes of tires and rims for original equipment, and the deletion from the S.A.E. HANDBOOK of detail constructional dimensions such as for rim contours and supplementary data, tire loads and inflation pressures, because of frequent changes in them due to commercial developments and, inasmuch as revised data are issued currently by the Tire and Rim Association, Inc., to all of the automotive manufacturers. The policy was approved and will obviate having the S.A.E. HANDBOOK contain data that is more or less obsolete at the time each issue is published and distributed.

Reports Approved by the Council

At the meeting of the Council that was held immediately following the Standards Committee meeting the

ARTHUR BOOR, OF THE WILLYS-OVERLAND CO.
Chairman of the Standards Committee

action taken by the Standards Committee on all of the reports, except as already mentioned in the report of the Ball and Roller Bearing Division on lock nuts and washers, was approved.

At the annual business meeting of the Society on Monday evening, Chairman Arthur Boor reported the action taken by the Standards Committee and the Council on all of the reports submitted and, except for the reports that had been withdrawn or referred back to their respective divisions, they were ordered to publication in the 1931 edition of the S.A.E. HANDBOOK.

Members in Attendance

Michel, C. A., *Vice-Chairman*
Bonnett, C. E.
Boor, A., *Chairman*
Bryant, E. J.
Burnett, R. S., Standards Manager
Clark, W. G.
DeLong, B. H.
Falge, R. N.
Haggott, W. S.
Heames, R. M.
Herrick, E. D.
Jandus, H. S.
Johnson, W. M.
Kalb, L. P.
Keys, W. C.
Larson, C. M.
Lemon, B. J.
Mougey, H. C.
Outcalt, W. J.
Packard, J. A.
Parker, Leo
Parsons, H. N.
Pierson, D. M.
Roberts, L. L.
Saladin, H. J.
Schorman, W. A. P.
Swain, J. G.
Upham, E. W.
Warner, E. P., President
Watson, J. M.
Wooler, Ernest
Zimmerman, O. B.

Guests in Attendance

Anglada, J. A.
Bethune, R. M.
Brown, W. C.
Buchanan, F. C.
Cullen, W. J.
Gibson, R. W.
Johnson, C. V.
Kirkland, Arthur
Knopf, C. L.
MacGregor, V. R.
McIntyre, G.
Mitchell, W. C.
Nutt, Harold
Oberg, Erik
Partenheimer, H.
Schippel, H. F.
Smith, C. W.
Wood, E. C.

Trailer Hitch Subdivision Holds Meeting

ON WEDNESDAY evening the Subdivision of the Motorcoach and Motor-Truck Division of the Standards Committee, that was organized to carry forward a standardization program on four-wheel-trailer pintle eyes and tractor-trailer fifth-wheel connections, reviewed a number of criticisms and suggestions on the pintle eye that had been suggested by the Subdivision at its meeting in Chicago last November. It had been suggested previously by the Subdivision that the dimensions for this eye be such as to give at least 80,000 lb. tensile strength with an ample safety factor when low-grade material is used. In general discussion, in which the standard eyes that have been developed by some of the largest four-wheel-trailer operators such as the American Telephone & Telegraph Co. were mentioned, it was felt that the subject should receive further study by the trailer manufacturing members of the Subdivision; and accordingly it was agreed that each manufacturer will submit drawings of the eyes he uses, together with data on the quantity in which each has been manufactured, so that a composite standard pintle eye may be developed.

A lengthy and interesting discussion by the trailer manufacturers' representatives on the subject of the proposed standardization of tractor-trailer fifth-wheel connections brought out many points which they feel will make the formulation and adoption of a standard a difficult matter at best. Various ways of approaching the problem and the effect that existing conditions, especially commercial ones in the trailer industry, have on standardization, were discussed.

Replies to a questionnaire that had been sent out by one of the trailer manufacturers to a number of his customers was interesting in that it showed that the majority of them are interested in standardization of this type of connection. It was felt, however, that not sufficient information of this character had been obtained by the Subdivision, and accordingly it was

agreed that a questionnaire would be prepared by the trailer manufacturers, together with suggestions to be incorporated in an accompanying letter as to the purpose and hoped for results of the standardization program. These and lists of the larger operating companies using tractor-trailer equipment will be sent to the Society's office for circularizing, and it is hoped that ample information will be received by this means for the Subdivision to make definite recommendations at its next meeting, which is planned to be held during the summer meeting of the Society at White Sulphur Springs, W. Va., in June.

It was indicated at the meeting that there will probably be definite standardization of motor-truck frame widths in the near future, and it was proposed that the Subdivision develop standard dimensions for mounting the lower half of the fifth wheel on the truck frame. The trailer manufacturers will prepare a tentative recommendation for circularizing among the truck manufacturers as soon as more definite information is available on the standardization of motor-truck frame widths.

Joint Meeting of Production Activity Committees

THE JOINT meeting of the 1930 and 1931 Production Activity Committees was convened at three o'clock on Tuesday afternoon, Jan. 20, by Vice-Chairman J. W. Brussel, in the absence of Chairman John Younger. Informal reports were submitted for Chairman J. Geschelin of the Activities Meetings Committee, reviewing briefly the Production Activity meetings during 1930. Chairman Brussel of the Membership Committee, reported that, due to the effect on the production engineers of the very unstable situation in the industry during the last year, it had been impossible to accomplish much toward increasing the production-engineering membership of the Society.

Mr. Brussel then referred to the paper on Machine - Tool Obsolescence, presented by L. A. Blackburn at the Production Session, Tuesday evening, as relating to a very vital problem in production engineering and suggested that, as the subject leads into production accounting, it should be followed through by securing data from a number of representative automotive manufacturing companies on the volume of machinery they have and how much of it has been obsoleted during the last two years. It was indicated that a study of this problem would involve such a great number of factors and variations that it could be a superficial one only, that might serve as a general guide.

Some stress was laid on the educational value to production men of such a study in making available to them useful information on production accounting that otherwise would not be available.

After appropriate concluding remarks by Vice-Chairman Brussel, Chairman A. K. Brumbough of the 1931 committee took the chair. In his remarks he emphasized that the Committee should have a definite objective to help the Committee and the Society to work out their own production programs that would result in the development and dissemination of data and information of real value to the industry.

Chairman Brumbough then discussed at length his suggestion to the Committee that the personnel problem in the production department of manufacturing is the most vital problem today in its economic and social aspects to manufacturing management and to employees. Mr. Brumbough said that, in studying this question prior to the meeting, it seemed to him that one big problem is the control of production labor with the recurrence of high and low points in the business cycle and how the production man can bring this problem to the realization of business managements.

A lengthy discussion of this subject by those present resulted in the Committee expressing the opinion that the matter should be studied by all members of the Committee. They should make suggestions as to vital points of the problem and how they should be studied and as to a program for effective publicity as soon as possible on the Committee's purpose in taking up this subject and on the results that it hopes to accomplish.

Chairman Brumbough stated that he would prepare his views and suggestions on the subject in written form for the members of the Committee as the basis for beginning such a general publicity program.

In discussing a further program for the Committee's work during the year, a number of subjects were referred to that had been suggested from one source or another during the last few months. Among these are the studies of the length of time parts should be carried in stock; on rust prevention during storage; on methods, formulas, and charts, for determining future uses of parts and materials; on use of separate machine-shops for service work; on systems employed to hold necessary tools for obsolete parts; on the scheduling of parts through the production and the service-parts-machining divisions; on relation of dealers' records to the manufacturer's spare - parts stock; and on micromotion applications and their relation to tool design.

A number of other subjects were mentioned, during the discussion of which it was felt by the Committee that a questionnaire should be sent to all members of the Committee giving them the subjects that had been suggested from various sources to the Committee and asking them to supplement this list with two or three of their own most vital problems for the Committee's study in connection with developing this year's program.

After discussion of the Activities Meetings program for the year it was agreed that the National Meetings Committee be requested to schedule one session for the Production Activity at the Semi-Annual Meeting of the Society at White Sulphur Springs, W. Va., in June, at which a paper on production-employment problems should be presented by an author who will be able to handle the problem effectively and reach manufacturing management with it.

Plans for the National Production meeting of the Society next Fall were next considered. It was decided that this meeting should be held in Detroit, probably during the second week of October, and that it should consist of four sessions, an evening session on Tuesday, afternoon and evening sessions on Wednesday and an evening session on Thursday.

It was felt that not more than two papers should be scheduled for each session and that the topics should be selected from the subjects now before the Production Committee, supplemented by those that may be submitted by the members of the Committee.

It was agreed that definite plans for the coming meetings as outlined above should be begun by the Meetings Committee of the Activity Committee without delay and that the next meeting of the Activity Committee should be held in Detroit as soon as the desired information regarding topics for papers has been collected for the Committee.

Sections Committee Meeting

THE Sections Committee met at breakfast in one of the most representative Committee meetings held in some time, with Vice-Chairman Norman G. Shidle in the chair, owing to the enforced absence of Chairman Lemon from the meeting the greater part of the time. Various phases of Section activity and ways and means for supplying to each of the Sections, from each other and from the main office in New York City, information that will be of help in producing good Section meetings were discussed.

The Cleveland Section plan of having a sponsor for each meeting named from among the older members of the Society was outlined to the representatives of the various Sections. Means for obtaining as complete Section representation as possible at future Section

Committee meetings were also discussed. Sections represented at this Committee meeting were Buffalo, Canadian, Cleveland, Dayton, Detroit, Indiana, Metropolitan, Milwaukee, Northern California, and Philadelphia.

Membership Committee Meeting

A JOINT meeting of the 1930 and 1931 Membership Committees was held Wednesday noon, Jan. 21, at which various phases of membership work of the Society were discussed.

Chairman F. K. Glynn, of the 1930 Membership Committee, reported on the work done last year and then Alex Taub, chairman of the Committee for 1931, discussed some of his plans for organizing the work for the present year.

The consensus of the Committee was that this year offers unusual opportunities for laying a strong foundation for future work.

Motor-Truck Chassis Subdivision Meeting

AT THE MEETING of the Motor-Truck Chassis Subdivision of the Motorcoach and Motor-Truck Division of the Standards Committee on Thursday afternoon, two phases of motor-truck frame standardization were discussed, namely: motor-truck frame width, and the dimensions from the back of the cab to the center-line of the rear axle. Among those attending the meeting were representatives of committees of the National Automobile Chamber of Commerce, the American Petroleum Institute and the Society, and a number of guests.

The meeting first reviewed the discussion of this standardization program at a meeting of motor-truck manufacturers and operators in Chicago last November and a joint meeting of the motor-truck standardization committee of the S.A.E. with members of the Motorcoach and Motor-Truck Division of the Society's Standards Committee and the N.A.C.C. Truck Standards Committee in New York early in January. A round-table discussion of the practice in frame widths on current models of motor-trucks followed, which indicated a trend toward rather general adoption of the 34-in. frame width on all makes of truck, especially in sizes larger than 1½ tons. Approximately 32-in. frames are used for some of the smaller sizes.

The principal factor in determining what frame width can be used is primarily, as brought out in the discussion, the 96-in. over-all width limitation imposed by the motor-vehicle regulations in several States and the development of high-speed large-capacity trucks equipped with large dual pneumatic tires. Mention was made of the possibility of some States changing their regulations to permit greater over-all widths of 102 in. or 106 in., but it was felt that any advantages gained in this direction would be absorbed by the necessary use of still larger tire sizes to carry the larger and speedier trucks that are sure to be developed in the future.

It was finally agreed as the sense of the meeting that it be recommended to the Society that a standard nominal width of 34 in. with a maximum tolerance of plus ⅝ in., minus zero, be adopted as standard for motor-truck frames.

The meeting then took up the matter of a series of standard dimensions from the back of the cab to the center-line of the rear axle, the series of dimensions as suggested by the West Coast Group of the American Petroleum Institute, the N.A.C.C. and Pierre Schon, being placed before the meeting. It was explained that the dimensions suggested by the A.P.I. West Coast Group represent a line of body-space dimensions that would adequately meet the requirements of the oil companies' tank trucks and that this series of dimensions could be modified to meet the requirements of various vocational operations.

It was indicated that the N.A.C.C. dimensions were a compromise of present motor-truck practice, while the latest suggested series of dimensions was the result of a careful analysis of dimensions advancing by progressive increments that will permit mounting standard bodies of all types and various capacities with desired load distributions between rear and front axles, especially on the longer-body jobs. It was pointed out that, for special requirements that must frequently be met by the truck manufacturer, any required length from the back of the cab to the center-line of the rear axle can be provided by shortening the next longer standard size. One immediate advantage of standardization of these motor-truck lengths, as pointed out by one of the motor-truck representatives, is that it has permitted his company to standardize on one cab and one position of the steering-gear for all of its trucks and also to reduce the variety of other parts, such as brake rigging.

Discussion of the question of what tolerances should be applied to the proposed chassis dimensions indicated that whatever permissible variation may be specified should be plus rather than minus, as variations in body lengths can always be taken care of where such allowance is on the plus side of the standard length. It was not felt at the meeting that a definite recommendation could be made on the amount of tolerance that should be specified until further data on the requirements in various classes of operation and types of body could be obtained by the Subdivision. It was finally agreed that each of the motor-truck manufacturers should furnish to the Society, tables of the dimensions from the back of the cab to the center-line of the rear axle for all of their current models, classified according to the types of load and body for which they are sold, and the tolerances within which they maintain these lengths. These data will then be compiled by the Society for distribution to the Subdivision members for further consideration. A questionnaire will also be sent to the National associations of the various classes of motor-truck operators and to others giving the following series of suggested dimensions from the back of the cab to the center-line of the rear axle and asking for information as to how close their present motor-trucks come to these dimensions and whether their operations will permit them to use trucks of these standard dimensions in their particular classes of operation.

SUGGESTED MOTOR-TRUCK-FRAME LENGTHS FROM BACK OF CAB TO CENTER-LINE OF REAR AXLE, IN.

39	72	120
48	84	138
60	102	156

As further progress is made with this program of standardization, information regarding it will be published in future issues of the S.A.E. JOURNAL and made available otherwise, so that both the manufacturers and operators of motor-trucks may be informed and participate fully in determining what the standard shall be.

Errors in A. M. Wolf's Article

IN THE article entitled Automobile Engineering Progress Disclosed at Shows, by Austin M. Wolf, which appeared in the January issue of the S.A.E. JOURNAL, several errors crept in. On p. 27 the illustration of the Bijur automatic lubricating system was inverted. On p. 28 in the fifth line of the first column the increase in wheelbase length for the Lincoln car should be 9 in. instead of 8 as printed. In the third line of the next paragraph cam-and-level should be cam-and-lever. Packard should be substituted for Buick in the list of cars using the Bijur automatic lubricating system as given in the second line of the last column. On p. 29 the last word of the sixth line of the second column should be fender not frame, and in the fifth line of the next paragraph in the same column section should be plural.

Personnel of S.A.E. Committees for 1931

AT an organization meeting of the 1931 Council, held in Detroit on Jan. 23, President Bendix announced his appointments on the Administrative Committees and the personnel of the Professional Activities, Technical and Special Committees as follows. Included in this list are the Research Committee and its Subcommittees, the Standards Committee and its Divisions, the Society's Special Committees, and other organizations in which the Society is represented. Acceptance of their appointment has not yet been received from all of those named.

Administrative Committees

Constitution Committee

W. T. Fishleigh, *Chairman* (1 yr.)

B. B. Bachman (2 yr.)
F. E. Watts (3 yr.)

Finance Committee

David Beecroft, *Chairman*

W. L. Batt
C. W. Spicer
J. W. White
C. B. Whittelsey

House Committee

R. H. Combs, *Chairman*

E. F. Lowe
F. A. Cornell
J. A. Anglada
S. R. Dresser

Meetings Committee

N. G. Shidle, *Chairman*

F. C. Horner
L. C. Hill
E. P. Blanchard
W. S. James

Professional Activities Representatives

Aircraft	Carl Harper
Aircraft-Engine	G. W. Lewis
Diesel-Engine	A. J. Poole
Motor-Truck	B. B. Bachman
Passenger-Car	W. C. Keys
Passenger-Car-Body	Roy Anderson
Production	Joseph Geschelin
Transportation	Adrian Hughes, Jr.

Section Representatives

Baltimore	A. Bruce Boehm
Buffalo	W. H. Schaefer
Canadian	F. N. Horton
Chicago	B. S. Pfeiffer
Cleveland	Hoy Stevens
Dayton	V. G. Apple
Detroit	A. J. Neerken (Body Division)
	Peter Altman (Aeronautic Division)
Indiana	George Freers
Metropolitan	A. M. Wolf
Milwaukee	Chester S. Ricker
New England	James A. Moyer
Northern California	Howard Baxter
Northwest	Robert S. Taylor
Oregon	H. W. Drake
Philadelphia	J. P. Stewart
Pittsburgh	C. F. Kells
Southern California	F. C. Patton
St. Louis	George F. Heising
Syracuse	R. N. Wright
Washington	L. D. Webb
Wichita	Mac Short

Membership Committee

Alex Taub, *Chairman*

C. S. Fliedner
G. O. Pooley
W. S. Peper
Gerald White

Professional Activities Representatives

Aircraft	C. B. Harper
Aircraft-Engine	G. W. Lewis
Diesel-Engine	L. F. Burger
Motor-Truck	C. F. Magoffin
Passenger-Car	Alex Taub
Passenger-Car-Body	Jacob Hammerl
Production	J. W. Brussel
Transportation	H. V. Middleworth

Section Representatives

Baltimore	Edward W. Jahn
Buffalo	A. F. Carlson
Canadian	A. N. Bentley
Chicago	R. E. Wilkin
Cleveland	A. A. Skinner
Dayton	V. G. Apple
Detroit	Alex Taub
Indiana	Charles Merz
Metropolitan	A. L. Beall
Milwaukee	Wesley B. Pusey
New England	William M. Clark
Northern California	Samuel Boukard
Northwest	G. P. Webster
Oregon	A. R. Trombley
Philadelphia	Henry Coleman
Pittsburgh	J. A. Harvey
Southern California	William Fairbanks
St. Louis	G. C. Stevens
Syracuse	R. B. Beauchamp
Washington	E. S. Pardoe
Wichita	Lloyd Stearman

Publication Committee

David Beecroft, *Chairman*

H. K. Cummings
G. W. Lewis
W. E. Kemp
A. M. Wolf

Sections Committee

*R. R. Teetor, *Chairman*

V. G. Apple (Dayton)
D. S. Cole (Cleveland)
R. H. Combs (Canadian)
H. C. Dickinson (Washington)
G. P. Dorris (St. Louis)
John Erskine (Chicago)
Murray Fahnestock (Pittsburgh)
C. P. Grimes (Syracuse)
W. C. Keys (Detroit)
Earl W. Kimball (Buffalo)
*Albert W. Lodge
J. F. Long (Northern California)
Neil MacCoull (Metropolitan)
Charles Merz (Indiana)
*F. E. Moskovics
F. B. Myers (Oregon)
F. C. Patton (Southern California)
G. O. Pooley (Baltimore)
Mac Short (Wichita)
J. P. Stewart (Philadelphia)
Robert Taylor (Northwest)
Glenn Whitham (New England)
Fred M. Young (Milwaukee)

*Member at large

Professional Activities Committees

Aircraft Committee

G. W. Lewis, *Chairman*
C. J. McCarthy, *Vice-Chairman*
E. E. Aldrin
C. H. Chatfield
J. W. Crowley, Jr.
C. B. Fritsche
C. W. Hall
C. B. Harper
C. W. Howard
J. C. Hunsaker
B. G. Leighton
Grover Loening
L. D. Seymour
Mac Short
W. L. Smith
W. B. Stout
E. E. Wilson
Orville Wright
T. P. Wright
C. M. Young

Aircraft-Engine Committee

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Robert Insley, *Vice-Chairman*
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John Geisse
E. D. Herrick
G. W. Lewis
W. L. Smith
C. F. Taylor
P. B. Taylor
T. E. Tillinghast
N. N. Tilley

Diesel-Engine Committee

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R. J. Broege
L. F. Burger
Harte Cooke
C. L. Cummins
H. C. Dickinson
C. S. Fliedner
J. B. Frauenfelder
H. D. Hill
H. L. Horning
J. H. Hunt
Carlton Kemper
D. W. R. Morgan
J. F. Max Patitz
A. J. Poole
J. Otto Scherer
P. H. Schweitzer
M. J. Steele
G. N. Somerville
H. R. Sutphen
C. F. Taylor
O. D. Treiber
Marsden Ware

Passenger-Car Committee

E. S. Marks, *Chairman*
W. C. Keys, *Vice-Chairman*
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G. C. Brown
R. E. Cole
J. M. Crawford
W. J. Davidson
W. N. Davis
W. T. Fishleigh
W. R. Griswold
K. L. Herrmann
L. P. Kalb
F. F. Kishline
B. J. Lemon
G. L. McCain
Ivan Ornberg
D. G. Roos
Alex Taub
P. L. Tenney

Passenger-Car-Body Committee

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A. J. Neerken, *Vice-Chairman*
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Hermann A. Brunn
Oliver Clark
W. N. Davis
W. H. Emond
George Grimm
Jacob Hammerl
L. C. Hill
E. E. Lundberg
Amos Northup
C. O. Richards
M. H. Toncray

TRANSPORTATION AND MAINTENANCE COMMITTEE

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A. S. McArthur, *Vice-Chairman*
J. C. Bennett
C. H. Bolin
O. M. Brede
O. R. Cole
A. F. Coleman
J. W. Cottrell
Henry Dakin
Harlon W. Drake
W. J. Duffy
W. H. Fairbanks
E. Favary
N. A. Finch, Jr.
A. H. Gossard
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Marmon Wins Metropolitan Medal

Award for Most Noteworthy Passenger-Car Development Made at January Meeting—Year's Automobile Improvements Reviewed

METROPOLITAN Section's annual dinner party at the Hotel Commodore, New York City, on Monday of Show Week, lived up to its reputation as a "sell-out" by hanging the S.R.O. sign long before the doors opened. Over 500 attended, the registration being about equally divided between New Yorkers and big bolt and shackle men from the West.

The high spot of the affair was the presentation of the Metropolitan Section Medal for Passenger-Car Design to Howard C. Marmon as the individual responsible for the most noteworthy passenger-car development of the year. Preceding its presentation by Past-President W. G. Wall, the sponsor for the medal, Fredrick E. Moskovics, was introduced. His brief remarks were humorous, somewhat philosophical and thoroughly optimistic.

Mr. Wall spoke for the medal committee consisting of Herbert Chase of the McGraw-Hill Co.; T. J. Lítle, Jr., of the Holley Carburetor Co.; N. B. Pope, editor of *Automobile Topics;* T. C. Smith of the American Telephone & Telegraph Co.; and Mr. Wall. After much discussion, the committee had decided, said Mr. Wall, that the engine of the new Marmon Sixteen merited recognition as the year's most noteworthy accomplishment in passenger-car development. The medal was therefore presented to Howard C. Marmon, the engine's designer, with special mention of its (*a*) light weight-power ratio, (*b*) compact and highly refined design, (*c*) new and apparently practical method of introducing cylinder liners, (*d*) consistent and well studied application of light-weight alloys and (*e*) its further development of the economical block construction.

Dinner Establishes High Mark

The dinner itself, right up to the ice-cream cake with doves and angels rampant surrounded by edible clouds, was enough better than the Commodore's best to set a record high mark at which sponsors of the other 999 Show Week dinners might aim. More angels without doves—without, in fact, any accessories other than radiator ornaments and skid chains—were an intriguing part of the entertainment. Petite blond twins danced and sang, angel fashion; three acrobatic Gypsies turned flips and flops, angel fashion; a vivacious brunette warbled sweet nothings into the ears of those at the speakers' table, much to the amusement of the rest of the audience; and as a grand finale a motor pageant of 1931 arranged by Roy Perkins, head of the Poppycock and Folderol Division of the National Broadcasting Co., was presented.

The scheduled speakers were Harry L. Horning, president of Waukesha Motor Co.; Athel F. Denham, field editor of *Automotive Industries;* and O. T. Kreusser, director of the General Motors Proving Ground. Chairman Austin M. Wolf presided.

Horning Describes Engine Improvements

Mr. Horning not only told what developments have been brought out in 1931 passenger-car engines but also gave his authoritative and valuable opinion as to the merits of each alleged improvement. As an engineer, he questioned whether sound methods of construction are not in many instances being sacrificed to obtain horsepower of the A.D. (Advertising Department) variety. Mr. Horning commended specifically Packard's manifolding, the Hudson and Chrysler oil cooling and Marmon's efficient new 16-cylinder engine design. He good-naturedly poked fun at Buick for multiplicity of air, water, gas and what-not controls and gadgets and at Oakland for the mysterious "tin-coated" piston about which even Oakland engineers seem to know very little. He mentioned a number of engines in the 200-hp. class, saying that only over-production of gasoline and the location of gas stations near together permits operation of such machines.

HOWARD C. MARMON

Other factors discussed by the speaker included carbureter-air silencers, vibration dampers, rubber mountings, combustion-chamber design, iron versus aluminum pistons, valves and valve springs and bearings for sixes. "This year," said Mr. Horning in closing, "will see some great improvements in lubricating oils and systems. The outstanding features of 1931 engines are power, acceleration, speed and silence."

Chassis Developments Discussed by Denham

The second speaker, A. F. Denham, talked of chassis developments as disclosed by 1931 cars. His paper was a careful compilation of the details of chassis-design changes with particular attention to multiple-step sliding-shift transmissions and free wheeling together with the chassis changes associated with the adoption of such devices.

Kreusser Talks on Bodies

O. T. Kreusser, the third speaker, deplored the similarities so evident in all the elements of body design despite the many advances being made. He characterized elimination of applied moldings as a great forward step. He spoke of the slanting windshield and of difficulties to be overcome in securing satisfactory door hanging. The tendency toward convertible body styles is giving us strong, light top sections and roofs, said Mr. Kreusser.

Insulation from engine heat is receiving serious attention, but stuffing holes with "bull's wool" is far from being a solution of this problem, in Mr. Kreusser's opinion. Elimination of wind noises to obtain quiet will necessitate further streamlining and this, said the speaker in conclusion, will make the body engineer responsible for design in front of the dash as well as behind it.

The February meeting of Metropolitan Section is scheduled to be held at the A. W. A. Clubhouse, 357 West 57th Street, New York City, on the 18th, the subject being automobile-body aerodynamics.

Pittsburgh Hills Test Brakes

Symposium with Five Speakers Brings Out Record-Breaking Attendance of 244

THE Pittsburgh Section started the new year right on Jan. 15 with 157 paid dinner guests and a total meeting attendance of 244, thus breaking all its attendance records. The attraction was a five-speaker symposium on the subject of Brakes which was held at the Carnegie Institute of Technology.

Prof. J. W. Trimmer, of the Carnegie Institute, presided and introduced Lewis W. McIntyre, Pittsburgh traffic engineer, who made a hit by asserting he could stop as accurately as any car, and then placing his own watch and stop-watch on the table, to make sure the green, yellow and red lights, which had been so thoughtfully provided by the Pittsburgh Section to warn speakers of the approach and end of their 20-minute sessions, operated properly for, he said, "Stop lights don't always work."

What Constitutes Adequate Brakes

Mr. McIntyre told how in 1929, under compulsory inspection of 1,450,000 automobiles, 25.9 per cent had faulty brakes. The 1930 inspection showed 26.54 per cent needing adjustment and nearly 4 per cent needing relining.

"State laws that only require an automobile to stop from a speed of 20 m.p.h. within 50 ft. are obsolete," declared Mr. McIntyre. "Modern brakes will stop a car within 19 ft. at that speed."

For State laws merely to specify that a car must be stopped within a certain distance is not sufficient. That the car must be stopped safely is of special importance, continued the speaker. Practically all the braking effort may be on one side of the car, or on the front wheels. During emergency stops the car may be quickly turned from a straight course. Then unequal braking effort might throw the car out of control, thereby causing a serious accident.

In making a quick stop, Mr. McIntyre stated that careful observation will show that the front of the car drops 2 or 3 in. This results in a very material transference of weight and of braking effort which can be applied to front and rear wheels. Since manufacturers have taken advantage of this transfer of weight, manufacturer's instructions should be followed when adjusting brakes. Modern motor-cars should be supplied with brakes giving a braking effort of from 70 to 80 per cent of the weight of the car.

For brakes to be adequate, they should not only enable a stop to be made within legal limits, but the stop should be safe, properly equalized or proportioned, and sufficient reserve should be available to take care of the gradual deterioration that is bound to occur, concluded the Pittsburgh traffic engineer.

Air and Hydraulic Systems

The second speaker, Stephen Johnson, Jr., chief engineer of the Bendix-Westinghouse Automotive Air Brake Co., presented his paper on the Fundamental Characteristics and Design of Modern Air-Brake Equipment for Automotive Commercial-Vehicles, together with a large number of lantern slides showing the details of air-brake equipment as mounted on various chassis and also representative vehicles on which air-brake equipment is now being used.

LEWIS W. MCINTYRE
Pittsburgh Traffic Engineer.

The air compressor used for automotive brake equipment, said Mr. Johnson, has two air-cooled cylinders, either horizontal or vertical. The inlet valve is of the rotary type, but disc-type discharge-valves are used, because they have little inertia. The governor, or unloader, consists primarily of a tube similar to the well-known Bourdon tube used in pressure gages and a double-seated valve construction. When reservoir pressure reaches a predetermined point, say 90 lb., the tube is deflected, unseating the valve. The unloader has a 15-lb. range, so that when pressure in reservoir drops to 75 lb., the compressor is again loaded.

Among the advantages offered by the air brake are (*a*) it is instantaneous, flexible and yet powerful, capable of controlling the heaviest loads; (*b*) its direct application to the axle makes equalized forces possible; (*c*) it requires no physical energy, relieving driver of fatigue; (*d*) the air brake permits use of harder brake-linings, either composition or metal; and (*e*) air may be used for tire inflation and to operate auxiliary apparatus.

Owing to the illness of H. C. Bowen, of the Hydraulic Brake Co., the paper on Hydraulic Automotive Brakes was presented by J. R. Rose, Jr., of Wagner Electric Co., who told of the early development of the hydraulic brake, beginning when Malcolm Lockheed, then a young driver of racing cars, first fitted his own car with four-wheel hydraulic brakes. Like other pioneer inventions, these hydraulic brakes were ahead of their time, and it remained for the general development of the automobile to bring them into their present extensive use.

Mr. Rose showed a number of lantern slides featuring the various details of the design and operation of hydraulic brakes. He also exhibited a number of cut-away models of the various parts of hydraulic-brake operating-mechanisms, which were examined with interest by those present.

Mechanical and Booster Brakes

Professor Trimmer then introduced M. M. Cunningham, of the Bendix Brake Co., whose scholarly presentation on Motor-Car Brake-Effectiveness was well received by the members as an exposition of recent advances in the art of practical mechanical brakes.

Mr. Cunningham told how service men were largely responsible for the rapid improvement in mechanical brakes and how this had been further aided by the introduction of balloon tires. Brakes are essentially machines for converting mechanical energy into heat, he stated, and he gave the following brake formula:

$$\text{Kinetic energy} = 0.0334\ W\ N^2$$

where

W = the weight of car in pounds
N = the speed in miles per hour

With the effective aid of large blueprints, the speaker showed the manner in which mechanical brakes, of the two-shoe and the three-shoe type, could obtain additional power for their application through the principle of self-energization.

Mr. Cunningham also mentioned the desirability of the Society's standardizing brake-linings and hoped that this project would soon be consummated so a service man could identify and install brake-linings with the proper coefficient of friction in order that safe and satisfactory operation might be obtained.

The final speaker was R. P. Breese,

installation department manager for the Bragg-Kliesrath Corp., who showed a full-size working booster-braking system, operating with vacuum from one of the engines running in the laboratory in which the meeting was held. He effectively sketched on the blackboard the various hook-ups, both with and without booster systems and showed in a graphic manner the proportional forces exerted in various parts of the component parts of brake hook-ups. He also explained the manner in which the vacuum booster could be applied to the operation of hydraulic brakes.

Wheel Alignment Is New England Subject

MEMBERS and guests of the New England Section of the Society learned some very interesting things at the Jan. 13 meeting in the Hotel Kenmore, Boston, from President Will Dammann, of the Bear Mfg. Co., of Rock Island, Ill., about wheel and axle alignment and the causes of troublesome steering and shimmy.

Chairman Albert Lodge had Mr. Dammann and G. H. Kinter, of New Haven, representative of the Bear company, as guests of the Section at the dinner preceding the meeting. More than 150 were present when the business session began, a number of men from outside Boston helping to make it the largest meeting of the Section this season.

Mr. Dammann started with the premise that faulty axle and wheel alignment is the principal cause of weaving, wandering, jerking, hard steering and shimmy; also that scuffing, pitting, scraping and gouging of tires are largely the result of faulty alignment. He explained that the four principal relationships that must be maintained in the balance in the steering mechanism are pitch, toe-in, axle caster and wheel tracking. Misadjustment of any one of these upsets all four. Wheels must also be kept in balance and free from eccentricity, and the steering linkage must turn freely without looseness. Difficult steering and excessive play will result otherwise, he pointed out.

How the laboratory and experimental service of his factory carries through a systematic check-up, going over every possible source of trouble to determine its exact cause, was then explained by Mr. Dammann. He not only told how this work is carried on but told of new developments constantly arising that lead to complications which must be studied and overcome. Some of these are due to design and construction.

Very interesting was his account of the work done at the last Indianapolis 500-mile race, when his organization was asked to furnish alignment service for the racing cars. Many of these cars had been rebuilt, and it was necessary to make corrections of axle and wheel alignment to 30 out of the 38 machines that were entered.

Among the other things which the speaker touched upon that kept his audience very much interested was the effect of tire pressure on the steering angles. He said that a variation of 5 to 10 lb. causes an appreciable and measurable change in the pitch and toe-in of the wheels and in the caster angle.

Troubles and Remedies Presented Visually

A miniature model of a front axle, complete with springs, steering-knuckles and steering connections, was used by Mr. Dammann to fully illustrate the cause of steering troubles. The result of a forward or backward movement of the caster angle could readily be seen. A complete set of gages, shims and other devices used in wheel-alignment and axle-straightening jobs was also at hand, so that their operation could be demonstrated.

Slides were presented to give a complete picture of the troubles arising from many sources that put axles and wheels out of alignment. These were supplementary to the model.

Animated discussion followed, in which some points not touched on in the talk were brought out; for example, that too much front-spring lubrication may cause shimmy or make the car hard to control; that drivers often cannot differentiate between shimmy and road shocks; and that testing and correcting the wheel alignment of used cars would help to solve the used-car problem and make satisfied customers.

Taxes and Brakes Considered

Increased Taxation Opposed at Seattle—Speakers Analyze Brake Shop-Equipment and Methods

FOUR speakers, all of them dealing with some phase of the braking motor-car problem, were on the program of the January meeting of the Northwest Section, held Friday evening, Jan. 9, at the New Washington Hotel, in Seattle. Don F. Gilmore, Section Chairman, presided. Robert S. Taylor, former Chairman and head of the Program Committee, reported plans for having Prof. F. G. Baender, of the Oregon Agricultural College, give his long-talked-of address on Flame at the February meeting.

Attendance was very good at this, the first meeting of 1931. The speakers were John M. Wright, district manager of the Russell Mfg. Co., on the subject, The Braking Problem; C. A. O'Neill, of the Bendix Service Corp., on the topic, Cowdrey Brake-Testing Machines; Martin M. Fisher, president and manager of the Barnes & Fisher Co., on The B. & F. Brake-Shoe Grinder; and John T. Friedli, president and manager of the Friedli Recording Device Co., on The Friedli Brake-Testing Machine.

The principal part of the program was devoted to Mr. Wright's contribution, which consisted of three reels of motion pictures taking spectators through the Russell brake-lining manufacturing plants in Middletown, Conn., and a short talk principally devoted to brake-linings.

Opposes Increase in Taxes

A special report was made by Charles Finn, treasurer of the Section and a member of the Seattle Chamber of Commerce Traffic Committee, who spoke in opposition to the proposal of a flat $3 motor-vehicle license fee and a gasoline tax of 4 cents per gallon. The present State gasoline tax is 3 cents, 2 cents for State Highway purposes and 1 cent going to Oregon Counties. His opposition was based on inability of the change to produce sufficient revenue to carry on the program of State highway expansion and maintenance. He admitted that the gasoline tax was a fair one for the measure of road usage but declared a higher tax than 4 cents per gallon is not favored. Then the problem would be to figure out the flat license fee with a 4-cent gasoline tax instead of the present 3-cent tax. A flat fee of $8 regardless of weight, or of $6 or vehicles weighing less than 2500 lb. and $12 for those weighing more, would result in about holding revenue up to requirements, he said.

Cost for maintenance per mile of State highway, non-paved, declared Mr. Finn, is $700 per annum, and for paved highways, $50. Oiling highways has proved costly and has not given a lasting surface, because of climatic conditions in Washington. In the Olympic Peninsula, where the best form of this work, oil mixed with gravel, was done, the highway broke up in from 18 to 30 days. "The State cannot afford to slow up on its paving program," said Finn. There are now 3200 miles in the State highway system, and it is planned to add 1400 miles more this year, he said.

Brake-Testing Machines Described

Mr. O'Neill explained the mechanism of the Cowdrey brake-tester and gave reasons for the Bendix Aviation Corp.

selecting it. "It gives actual road tests, and just what the vehicle will do on the highway can be scientifically and accurately computed from the results," he declared. "It gives a true story for the action of each wheel. The reading is in pounds showing pressure on the brake-drum of each wheel."

Two reasons given for not having more speed in the machine were that accurate readings would then not be possible and higher speed would cause heating of brake-drums. High or low spots can be accurately located at a slow rate of speed, which would be impossible if the machine were speeded up.

Mr. Friedli explained the development of his recording device since 1925 and told of its acceptance by officials in all Pacific Coast States and 11 eastern States. The pendulum principle is involved in his instrument, which is clamped on the running board or placed on the floor of the vehicle. "We weigh retardation," he said, "and obtain simply the stopping distances on the road at various speeds showing deceleration in feet per second. We do not obtain equalization but do get actual performance. Tests can be made in about 1 min. A recorded certificate is automatically punched as it is withdrawn from a slot in the machine, this showing the swing of the pendulum."

Repair-Shop Brake-Equipment

Mr. Fisher described how the B. & F. grinder for brake-shoes gives as nearly as possible 100-per cent contact on the brake-drums. The machine has graduated scales for measuring drum diameters and setting micrometer adjustments on the ball-crank handle and positive stop. It has a capacity for brake linings for drums 10 to 24 in. in diameter and 1 to 7 in. wide. A ¼-hp. motor is used. The grinding wheel is an 8 x 3-in. cup, made of sharp grit bonded with Bakelite. This, he said, provides a wheel that runs free and cool, because of the open structure which dissipates heat, not loading or gumming on the softest lining.

Mr. Wright called his paper Looking Brake Problems Squarely in the Face. He admitted that the problems are not yet solved, although advances are being made continually. "There are a number of good brake linings," he said, "and 90 per cent of brake troubles are not due to the linings, although it is natural to blame the lining. The fault may be with the lining or the mechanic, or, again, with neither, for there are certain inherent shortcomings," he stated. Drum scoring usually begins early after a relining job has been done, and he urged care in the use of brakes after relining.

"If a car owner would be half as careful with relined brakes as he is in breaking in a new car, scoring would be reduced to a minimum," he said. "However, the driver generally wants to show how well his brakes work and he makes sudden stops."

For the well - equipped brake - shop, Mr. Wright advocated the following equipment: drum lathe, countersinking and riveting machine, brake-tester or equalization machine, brake - shoe grinder to increase the area of contact, and drum gage.

"The result desired is, of course, to do an accurate brake job. Cheap drums and cheap lining are poor economy," he said, "the best being the cheapest in the long run." His discussion was concluded with an analysis of various grades of asbestos. He advocated calling the work of relining brakes by the more inclusive phrase, "complete overhaul of the brake system."

A Professorial Aircraft Meeting

Oregon Section Donates a Fusselage to Oregon State College and Gets Lectured

FURTHER demonstrating its active interest and cooperation in things aeronautic, the Oregon Section devoted its entire Jan. 9 dinner meeting to the aviation theme, paying its particular respects to the new aeronautics course at Oregon State College.

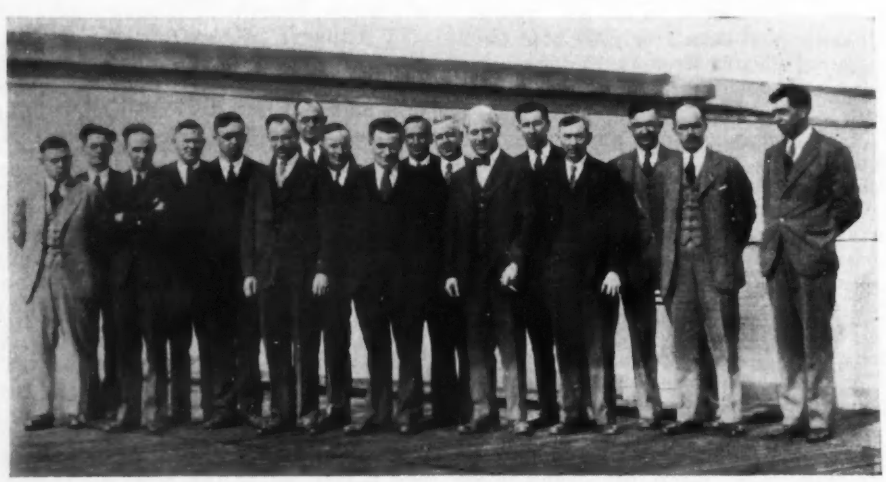
It was for the benefit of this college course that the meeting was held. Five Oregon State College professors were on the list of speakers, four of them presenting papers, and formal presentation was made to the school of an airplane fuselage, wings and other airplane parts for use as laboratory equipment.

The Oregon Section took the initiative in calling for these gifts. Portland aviation firms did the rest with generous response. H. W. Drake, chairman of the section, in making the presentation, acknowledged the aid of these companies—the First National Flying System, Inc.; Tex Rankin School of Flying; Pacific Machinery & Tool Steel Co.; Breese Aircraft Corp. and the Adcox Auto & Aviation School. "It is our hope that this will serve to create an interest which will be far more important than that which we have done," said Chairman Drake, in turning the gifts over to the school.

Prof. F. G. Baender, head of the department of mechanical engineering at the College, responded, expressing the school's appreciation and telling of the student attention shown the new course.

Three aviation officials preceded the professors on the speaking program. George L. Sammis, president of the Aero Club, Portland chapter of the National Aeronautics Association, spoke of the assistance given by the Oregon Section of the S.A.E. to aviation development in the past; L. L. Adcox, president of the Adcox School, briefly described work being done at his school on a new light airplane engine designed by J. Harry Groat; and Tex Rankin, head of the Tex Rankin School of Flying, made a few promising predictions for aviation in 1931.

That 1931 will be the real beginning of commercial aviation and that it will be the most profitable year aviation has seen, were some of Mr. Rankin's forecasts. The 1930 oversupply of planes has been absorbed, factories are getting new orders and the industry's wheels are beginning to hit their pace again, he said. He spoke, too, of new markets for planes, particularly that to result from increased interest in private flying. Among others, hundreds of professional and business men will learn to fly and will purchase their



LUNCHEON GROUP AT PORTLAND AIRPORT IN NOVEMBER

SECTION MEMBERS ON VISIT TO ADCOX SCHOOL FOLLOWING FRIDAY LUNCHEON IN DECEMBER

own craft in the new year, he predicted.

Leading off the papers presented by the Oregon State College professors was that entitled Training in Aeronautical Engineering, by H. S. Rogers, dean of the School of Engineering, director of the Engineering Experimental Station and head of the Department of Civil Engineering.

Four types of training to serve the aviation industry were cited by Dean Rogers. These are flight training; training in construction, production and maintenance; training in aeronautical engineering, directed primarily toward the design of planes; and training in the management and operation of airports and air traffic.

Giving information on the Oregon State College aeronautics course, Dean Rogers said that two standards had been set; one, to obtain the services of competent instructors closely in touch with their subjects, and the other, to obtain suitable laboratory equipment. While the school could use approximately $250,000 worth of laboratory equipment, he said, it is not poorly provided for, having some of the finest equipment in the West.

The hope in starting the new course, according to the dean's paper, is to develop a strong undergraduate course. As established, the course is an option in mechanical engineering. Because of the wide variety of subjects studied, the dean expressed belief that those taking the new course "will have as broad a knowledge as any students going into other branches of the Engineering Department."

Interesting comparisons between aviation activities in the United States and those of the British Isles were drawn by Prof. Walter R. Jones, professor of aeronautical engineering, in his paper on The Aircraft Industry in Great Britain.

Professor Jones recently visited the British Isles to look into aviation there. Purchasing a car, he traveled 'round and about, getting a close insight into the aeronautical workings on the other side.

The British aircraft industry still is almost entirely dependent for its existence on requirements of the Royal Air Force, he found. Because of relatively small distances between important centers and frequent and fast rail service, there is no necessity for organized air-transport within the islands. For several years regular air-service has been maintained between London and the important centers on the Continent, under government subsidy, but the demand for equipment of the type used is a small factor in the industry.

Professor Jones found a noteworthy development in England of the sport or light plane, usually a two-seater powered with an engine of about 100 hp., selling at $2,000 to $4,000. In this connecton, a number of light-plane clubs have been formed, also subsidized to a small extent by the Government.

A high state of efficiency has been reached by military aviation in England, the professor said. Diverse types of plane and highly specialized craft are of interest. Whereas earlier English designs were clumsy, planes of today present a pleasing ensemble with evidence of careful attention to detail.

The paper reported further that, in contrast with the case in this Country, there has been no marked tendency toward the exclusive use of air-cooled engines, both air-cooled and water-cooled types having been developed. There also has been development of the compression-ignition engine, of the type used in the ill-fated dirigible R-101.

The extensive employment of metal is a characteristic of airplane construction in Great Britain. Frequent use of high-strength alloy steels, as yet virtually unused by the aircraft industry in the United States, according to the speaker, is a feature. A factor in the preference for alloy-steel construction is the dependence on foreign sources of raw material "which might cause embarrassment in time of war," read the paper. The material used is a chromium-nickel-alloy strip steel, the strength usually being defined in "tons proof."

Professor Jones mentioned ingenious methods of British manufacturers for producing closed sections of high structural efficiency, with strips up to 120 ft. long being put through rolls, electric furnaces, water-cooled dies and electric hardening furnaces, to emerge as perfectly formed heat-treated sections. He described still other manufacturing processes for riveting external attachments to closed sections, for drawing tubes with thin walls to sufficiently uniform wall thickness and for turning out standardized machined fittings, bolts and rivets.

Professor Jones's paper was illustrated with slides showing airplanes, airplane plants and construction details which he observed overseas.

Development of Welding Processes

Slides also were shown with a paper on Welding from the Metallurgical Viewpoint, by Prof. S. H. Graf, director of engineering research at Oregon State College. The need for welding, the historical development of welding, present methods, methods used in plane construction, the nature of metals, the welding of light alloys, brazing and soldering were some of the points touched on.

Forge-welding of wrought iron, steel and copper dates back to antiquity Professor Graf said. Flash-welding by electric current was practised to a small extent as far back as 1890. Present methods, however, particularly in structural welding, have been developed in the last 20 years and greatly extended in the last three or four years. Welding processes are subdivided as resistance welding, arc-welding, gas-welding and thermit-welding. In plane construction, the oxy-acetylene torch, the electric arc and the resistance weld are used.

Professor Graf gave results of tests made on welds. Under impact, he said,

the gas weld usually proves superior to the ordinary arc weld, probably because of the more ready access of air to the arc-deposited metal with resulting oxide and nitride inclusions. The higher temperature probably also is a factor.

How the Army Air Corps tests its equipment and carries on its research activities was reported in the next paper, Activities at Wright Field, by Prof. J. C. Othus, assistant professor of mechanics and materials at Oregon State College. He also followed his talk with slides.

Professor Othus told of the engineering school founded at Wright Field in 1919 to train pilots for executive jobs in the Materiel Division, of the equipment for research at the field and of some accomplishments of this research work, such as parachute perfection and the cooling of engines by ethylene glycol. Professor Othus was employed as a metallurgist at Wright Field last summer.

Entertainment in the form of dancing and singing by some fast-stepping young women enlivened the Section's dinner for the approximately 100 present. At one end of the room in Multnomah Hotel, the airplane fuselage and other plane parts being given Oregon State College were displayed.

Chairman Drake outlined the program of the Section for the first six months of this year, including an outing at Longview, Wash., planned for the Northwest Section in June. He also spoke of the approaching visits to the coast of John A. C. Warner, General Manager of the Society, and A. J. Underwood, director of Section activities and aeronautics.

Weekly Luncheons a Section Feature

A feature of the Oregon Section's activities is the weekly Friday informal luncheons to promote the social and professional spirit of the members. The officers believe that this activity brings the members into closer relation and accounts for the whole-hearted cooperation that the officers have enjoyed. Two of these luncheon groups are shown in accompanying engravings. One is of a group which met for luncheon last November at the Portland airport because of the interest taken in aeronautics by A. J. Underwood, who was then visiting the group. As he was the only official member of the National organization to visit the Oregon Section since its formation a year ago, the members felt honored by this visit of a headquarters representative. Box lunches were served and an inspection tour of the airport was made.

On Dec. 19, following the weekly lunchean in the Multnomah Hotel, the group of a dozen members shown in another picture adjourned to the Adcox Aviation and Automotive Schools to inspect the school and also the fuselage which was being built there for the Section to be donated to the Oregon State College. Although not a member of the Section, Mr. Adcox graciously donated all the labor and welding materials for the job.

The Oregon Section cordially invites all members of the Society who may have occasion to go to Portland to make their presence known to officers of the Section so that they can make the acquaintance of their fellow members in Oregon and, if possible, attend a meeting or a weekly luncheon.

Great enthusiasm prevails among the members of the Section, which is planning a big Automobile Show Dinner in cooperation with local dealers and car manufacturers' representatives in the week of the Portland Automobile Show in February.

Met. Section Active in Safety Conference

UNDER sponsorship of the American Society of Safety Engineers, the Second Annual Greater New York Safety Conference is to be held on Feb. 25 at the Hotel Pennsylvania, New York City. Through Past-President Warner, the Metropolitan Section of the Society became interested in the cooperative safety movement and has taken a leading part in preparing for the Conference.

The Conference is to be held under the auspices of the Metropolitan Chapter of the American Society of Safety Engineers, Engineering Section of the National Safety Council. Thirty-five

JANUARY DINNER MEETING OF THE OREGON SECTION

Those at the Speakers' Table Are (Left to Right): Edward Dagner, of the Northern California Section; Prof. J. C. Othus, of Oregon State College; E. J. Blaser, of the Factory Motor Car Co., Portland; J. V. Savage, Treasurer of the Oregon Section; Prof. S. H. Graf, of Oregon State College; A. R. Trombly, of the Earl B. Staley Co., Portland; W. R. Jones, of the Willis-Jones Machinery Co., Seattle, Wash.; H. W. Drake, Chairman of the Oregon Section; Dean H. S. Rogers, of Oregon State College; H. W. Roberts, of the Roberts Motor Co., Portland; and Prof. F. G. Baender, of Oregon State College and Third Vice-Chairman of the Oregon Section

National and local civic and industrial organizations are cooperating. Among them are the civil, mechanical, electrical, mining, welding, illuminating, automobile and terminal engineering societies, the American Standards Association, the Motor Truck Association and various other industrial associations.

Attendance at the First Safety Conference, held last year, exceeded 900, and a larger attendance is anticipated this year. Papers on accident prevention in industrial plants, on the highways and in office buildings in the Metropolitan area are to be presented. An exhibition of safety devices and accident-prevention is to be made in connection with the Conference.

Dual-Drive Six-Wheel Vehicles

Heavy Vehicles of Two Types Described at Meeting of Northern California Section

During the dinner which preceded the scheduled meeting of the Northern California Section at the Athens Athletic Club in Oakland, Thursday, Jan. 8, Horace Hirschler, Chairman of the Reception Committee, presided at the usual roll call. An entertainment was given and very favorably received. The meeting brought out many of the old members who had not attended a Section meeting for some time.

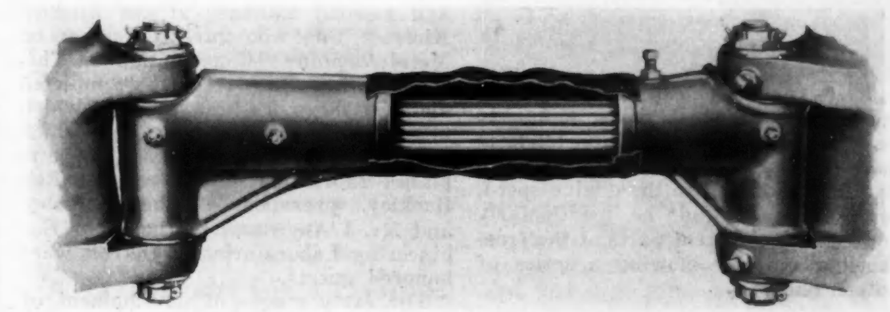
W. A. Eisman presented a brief outline of the purpose, organization and program of the Western Metal Congress, which is to be held in San Francisco during the week of Feb. 16. The sessions on the morning of Feb. 17 and the afternoon of Feb. 18 will be in charge of the Northern California Section, as representatives of one of the 12 National societies which are sponsoring the Congress. The February meeting of the Section is to be omitted, the members being requested to attend the sessions of the Congress.

Before the technical session there was a brief adjournment during which the Executive Committee met and voted an extended session for Jan. 20.

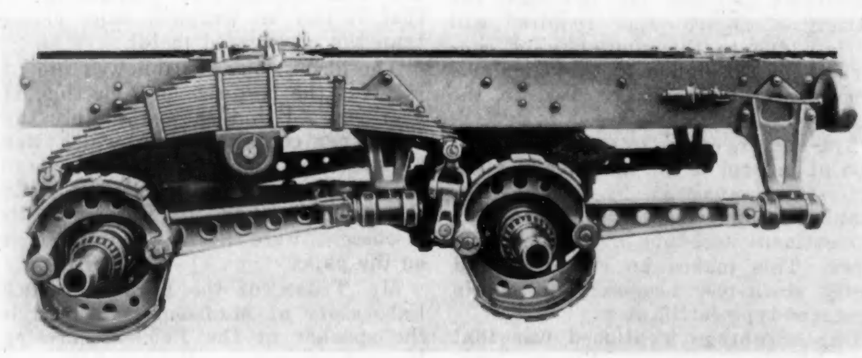
First in the technical session came a short introductory paper read by Mr. Croninger, research engineer of the Fageol Motors Co., on the subject of progress in motor-car design, in which he recounted some of the obscure but important improvements that have been made during the last one or two years, particularly in the way of building better service into motor-trucks. Notable among these have been the improvements in materials and in provisions for retaining oil in drive-shafts.

Bill Describes New Fageol Truck

Arthur H. Lacey then assumed the chair and introduced Theodore Bill, vice-president and sales manager of the Fageol Motors Co., who gave an illustrated paper on the new four-wheel-drive truck of that company. One of these trucks was on display in the front of the building and was inspected by the members during the recess preceding the session. The principal features of this truck are the rear-axle suspension, which allows some flexibility of axle position and provides support for the brake torque on four radius-rods, the torque spring between the two rear axles, and the rubber shackles provided to absorb the shock of the drive to the frame. Mr. Bill explained that the development of six-wheel trucks had been encouraged both by the greater gross-weight allowance provided by State laws for six-wheel vehicles and by the competition for hauling business which has caused a trend to reduce rates. He said that the dual-drive six-wheel truck can furnish transportation at lower cost per ton-mile than can four-wheel trucks, with or without six-wheel attachments.



Patented Torque Spring Connecting Driving Axles of Fageol Truck



Rear Suspension of Fageol Dual-Drive Truck

A Design with Three Differentials

John Small delivered the final paper of the evening, on the subject of Equalized Four-Wheel Drives. He described a dual-drive six-wheel construction in which a master differential having its axles parallel to the length of the vehicle is supported on the frame and driven by spiral-bevel gears from the propeller-shaft. Two bevel-gear drives containing differentials, located in line with the respective pairs of driving wheels, are mounted on the ends of the master-differential shaft. Four short universal-jointed shafts carry the drives from these differentials to the road wheels. The four driving road-wheels are mounted on the ends of two rocking-beams, which in turn are mounted on a tubular cross-shaft or axle midway between the front and rear pairs of wheels.

The first vehicles of this general design were fitted with master differentials of non-spinning type, but experiments on wet roads are said to have proved that there is no danger of stalling under any conditions with a master differential of ordinary type.

Discussion of the paper indicated doubt that the third differential is worth while. W. W. MacDonald and Mr. Croninger were among those who participated in the discussion, and considerable reference was made to the paper on six-wheel vehicles that was delivered at a meeting of the same Section in December, 1927, by Mr. Lacey. It was revealed that most of the material that must be handled in connection with the building of the Boulder Dam will be hauled on rubber tires. The conditions under which this work must be done will impose

severe problems on the manufacturers of motor-trucks.

Carl Voght will be sponsor for the March meeting of the Section, which probably will be held at the University of California.

Baltimore Discusses Free-Wheeling

THE January meeting of the Baltimore Section, which was held at Lord Baltimore Hotel on Jan. 21, will be recorded in the minds of many as being one of the most interesting of the current season from the standpoint of the discussion resulting from a talk on free-wheeling in automobiles. After a substantial dinner of the usual delicacies had been deposited safely, 98 Section members and guests, including several local automobile dealers who attended as representatives of the Automobile Trade Association of Maryland, directed eyes and ears to a delightful entertainment of singing and dancing, a program arranged under the direction of A. Bruce Boehm of the Reception Committee.

W. W. Smith, service engineer of the Studebaker Corp. of America, spoke on the most popular topic in automobiledom at the present time, Free-Wheeling. Its various phases of construction and operation, which allow a car to coast whenever its momentum tends to make it travel at a higher speed than that corresponding to the engine speed, were outlined, and he particularly pointed out competent parts of the free-wheeling unit by showing a series of lantern slides.

Service Engineer Describes Device

In his talk Mr. Smith said, "The Studebaker free-wheel transmission is of conventional design except for the use of helical gears and the free-wheel device that is located as a shifting member between the high and intermediate gears. Low and reverse gears are of conventional spur-gear design and two pairs of quiet helical gears are always in mesh." One pair of these last-mentioned gears is located at the forward end of the transmission and drives the countershaft. The other pair gives the second-speed reduction to the main splined-shaft. The second-speed main-shaft gear runs freely on its shaft as opposed to the usual construction of having this gear splined to the shaft.

"The free-wheeling unit," continued Mr. Smith, "consists of an inner cam-member splined to the main driven-shaft and free to be moved forward or back into high or intermediate-gear positions. This cam-member supports an outer shell or sleeve having internal teeth at each end arranged to engage corresponding toothed-clutch members on the forward pinion-gear or the rear second-speed gear. Interposed between the inner cam-member and this outer shell are 12 rollers, arranged in three groups of 4 each, which are held in contact with both members under a light spring-tension. This combination of inner and outer members and rollers is arranged so that driving torque will be transmitted from the outer member to the inner only in the driving direction. When the free-wheel unit is shifted forward so that the outer member only is in clutched engagement with the main driving-gear, the driving torque is transmitted through the roller clutch to the main driven-shaft and thus to the rear axle, giving high gear. Likewise, when the unit is shifted rearward until the outer member is in clutched engagement with the second-speed gear, a one-way second-gear connection is obtained."

Secretary Bavett announced that ballots for the election of a committee whose task will be to nominate candidates for Section officers for the next administrative year had been forwarded to all members. These committeemen will be elected next month.

Metal-Airplane Construction

Frank Smith Outlines Development and Discusses Advantages Before Wichita Section

THE Wichita Section's first meeting for 1931 was held at the Green Parrot Inn, Jan. 12. After the minutes of the previous meeting were read, the meeting, which was attended by 30 members and guests, was turned over to Frank Smith, vice-president and general manager of the Buckley Aircraft Co., who gave his paper on Metal-Airplane Construction. This organization has recently completed and test flown its first airplane which is all metal but the tires and which shows considerable promise for airplanes fabricated out of metal. Roy Buckley, president of the company, and Mr. L'Amoreaux of the Stout Engineering Laboratories of Detroit were honored guests.

The early stages of development of metal aircraft were outlined in the paper, showing how the same type of grit that made airplane flight a possibility made metal construction an actuality in place of a dream. Through lessons learned in building a Navy all-metal airplane, a large tri-motored transport machine now so common to all was evolved.

Mr. Smith pointed out how imperative metal construction is from standpoints of fire resistance, lessened cost of maintenance, resistance to climatic conditions and last but not least the variety of skilled labor required will be less due to the similarity of construction throughout the airplane. Sheet-metal workers are used in the main.

The one drawback to metal construction at present is the inability to work out stress analysis by simple mechanics as can now be utilized by the conventional steel-tube or wooden structures. This makes an elaborate and costly static-test necessary to obtain approved-type certificates.

One advantage mentioned was that ice will not form as readily on duralumin as it will on steel and especially when the duralumin has been anodized. The strength-weight ratio of this material is a point in its favor.

Rivets should be bought in the 17 SO condition and heat-treated just before using. The lack of knowledge in riveting practice has been the cause of much worry and while the author's explanation of some of the cures were found extremely beneficial, more study of this type of material is warranted. Duralumin rivets should not be used with aluminum due to the galvanic reaction between the various alloying elements in the rivet and the aluminum. The presence of these elements in the duralumin is one reason why it corrodes more rapidly than aluminum, but with proper protective coatings this can be overcome when sheet duralumin is used but cannot be overcome when duralumin rivets are used with aluminum sheets.

The cost of jigs and dies for metal construction, contrary to public opinion, is less than for conventional steel and wooden ships. Corrugated and plain sheet each have a definite place in metal-airplane construction. The former, being stiffer, is advantageous for wing construction and, therefore, eliminates internal drag-bracing. In fuselage construction the smooth skin has been found very satisfactory in that it can be wrapped more closely than the corrugated metal.

The discussion that followed the paper was the best the local Section has ever enjoyed and showed plainly that the paper contained data which were of interest to all. At times the train of thought wavered a bit but under the steadying hand of Mac Short the discussers were led toward questions on the paper.

Mr. Truax, of the Forest Products Laboratory at Madison, Wis., will be the speaker at the Feb. 12 meeting. His subject will be Gluing of Wood in Aircraft Construction.

Carbureter Progress and Action

Rich Mixture of Interest and Instruction Fed Southern California Section Members

SOUTHERN California Section's carbureter meeting, held in Los Angeles at the Alexandria Hotel ballroom, Jan. 9, resulted in a rich mixture of interest and instruction. More than 100 members turned out to listen to a program of well-informed speakers. During dinner the assemblage was entertained with lively airs rendered by a rhythmic orchestra. A number of leaders in the automotive industry, including the famous Frank Elliott, who lent a racy touch to the occasion, attended.

Chairman F. C. Patton opened the session with an announcement of the next regular meeting, which will deal with the subject of fire-engines. Several prominent authorities are scheduled to divulge the engineering side of blaze-battling apparatus. The Section's annual winter dance was also announced, the time and place being March 7 at the Alexandria.

O. H. Ensign, president of the carbureter company that bears his name, offered a very complete treatise on the delivery and effect of internal-combustion-engine fuel. He began with his earliest experience in this field—a railroad speeder, which he operated back in the eighties. In a comprehensive manner, Mr. Ensign built up carburetion development from the old days to the present. He backed up his contentions with curve charts of actual tests, which were thrown on the screen. As an indication of the extensive work still going on in the fuel-delivery field, the speaker mentioned that at present 18,000 carbureter patents have been granted. He considered such intensive activity as proof that continued improvement may be expected in this particular branch of automotive engineering.

Next, a dissertation on the action of gasoline in carbureters was delivered by W. I. Gieseke, of the Bendix-Stromberg Carbureter Co., who illustrated his remarks with a series of charts. He began with an elementary illustration of his subject, using the combination of air and fluid being drawn from a glass through a syphon straw. From this simple example, he led his listeners through the various stages of carburetion up to the present more complicated but highly efficient mixture devices.

Frank Doering, of the Doering Gas-ing Eliminater Co., gave a brief outline of his attachment designed for motorcoaches. The device, as he explained, protects passengers from unpleasant gas attacks by neutralizing the carbureter so that at idle speeds only pure air flows through the engine.

The meeting was then thrown open to general talk on the subject at hand. E. Favary, of the Moreland Motor Truck Co., reminisced interestingly on the ups and downs of carbureter experimentation 25 years ago.

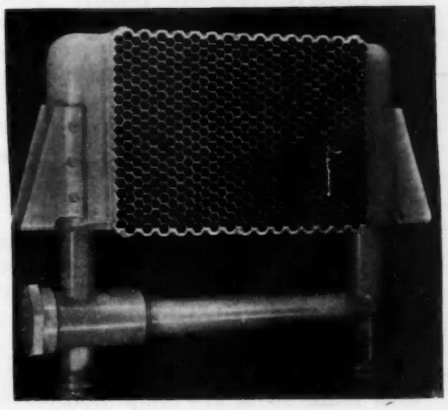
L. M. Griffith, mechanical engineer at the R. K. O. studios, Hollywood, challenged Mr. Ensign on some phases of the latter's lecture. A lively discussion on the load-speed-gear question ensued, and many members were drawn into the argument before the matter was thoroughly threshed out.

In defense of fuel manufacturers, H. T. Ramsey, of the Standard Oil, Co. of California, took the floor to remind the members that chemists and engineers are working constantly with engine manufacturers in an endeavor to combine the elements of quick starting, acceleration, power and economy into a perfectly balanced gasoline.

A Cold Night for a Cooling Subject

EIGHTY-TWO members of the Buffalo Section braved the storm and an approximately zero temperature on the evening of Jan. 21 to hear W. R. Ramsaur present his paper on Oil Cooling and Oil Coolers. Those who attended the meeting, which was held at the Hotel Statler, were well repaid, as the author was thoroughly competent to discuss the subject. After being graduated from the Massachusetts Institute of Technology he worked on oil cooling for 2½ years at the General Motors Corp. Research Laboratories, where he studied the fundamentals of oil cooling. Later he was transferred to the Harrison Radiator Corp. where he made a further study of the subject. The paper, which is the same as the one Mr. Ramsaur presented at the Annual Meeting of the Society at Detroit on the preceding day, is tentatively scheduled for publication in the April issue of the S.A.E. JOURNAL and only a brief outline is presented herewith.

After stating that the increases in horsepower, compression pressure and engine speed, which have occurred in the last five years, have imposed additional duties on the lubrication system, the author stresses the point that the most serious of the troubles resulting from the use of oil temperatures exceeding 300 deg. fahr. on the road is bearing failure. To reduce this temperature to a figure of between 210 and 230 deg. fahr. heat must be dissipated from the oil at a rate in excess of 250 B.t.u. per min. or a heat equivalent of approximately 6 hp.



AN OIL-COOLER FOR AVIATION USE HAVING 614 TUBES

This Unit, of the Air-Cooled Type, Is of the Same General Character as Those Used in the Tests Described in the Paper

At present two types, one using air and the other water as the cooling medium, are available. The former is extensively employed in connection with air-cooled engines, particularly on airplanes, but the latter is in more general use on automobiles. After listing the six requirements of a satisfactory oil-temperature control unit, the author describes a number of tests that were made to determine the relative effectiveness of the two types of cooler as regards the dissipation of heat in the oil. Lantern slides of charts giving the results of the various tests and the different types of cooler supplemented the presentation of the paper.

Questions High-Speed-Engine Superiority

REFERRING to discussion, printed in the S.A.E. JOURNAL for September, 1930, p. 305, on Alex Taub's Semi-Annual Meeting paper entitled, Powerplant Economics, F. Strickland, of Boynton Hall, Bridlington, England, a Foreign Member, recently wrote to the Society as follows:

I beg to differ from several of the speakers, notably Mr. Maynard, on two essential points. He and others take for granted, first, that the high-speed engine is necessarily lighter than the moderate-speed one; and, secondly, that it is more economical of fuel.

I disagree on both points. When the cylinders are reduced to very small dimensions and the revolutions are raised excessively to get the horsepower, the inertia forces become very great. In order to take care of these, the crankshaft, crankcase and bearings are made very large. By the time these have been made large enough to make the engine stand up to its work, it is usually heavier than an engine of more moderate speed.

I have been conversant with the automobile trade for 30 years but I see no drastic decrease in weight per horsepower, in spite of the fact that far better materials are available than formerly. Twenty-five years ago it was possible to obtain cars that weighed, with body and all, well under 3300 lb. with from 80 to 100 b-hp. and capable of speeds of over 80 m.p.h. With modern materials, these powers and speeds could be greatly exceeded with the moderate-speed engine, but the high-speed engine does not often equal them, and 80 hp. is a very high horsepower for a car of this weight now.

We have again an excellent example in the model-A Ford. This is made in England with 3-in. cylinders as a fairly high-speed engine, and the crankshaft and other parts are even then on the small side for cylinders of this size run at high speed. Yet the same crankcase, crankshaft and so on are ample for the American Ford with 3⅞-in. cylinders developing somewhat greater brake horsepower at much lower revolutions. Obviously, both the engine and car of the moderate-speed type are the lightest per brake horsepower.

As to economy on the road, we had in 1905 and 1906 two races in which the sole limits for the engine were fuel consumption. The only problem as regards the engine was to get the greatest power from a given consumption. In all cases the big-cylinder slow-running engines won, and the small-cylinder high-speed engines lost. In recent races in France the same thing has happened, and the 4000-r.p.m. engines have been quite dropped when fuel was measured.

In 1911 a Rolls-Royce with six 4½ x 4¾-in. cylinders went from London to Edinborough and back entirely on top gear carrying a load of 1550 lb. on the chassis and averaged 24.32 miles per English gallon (about 20.3 miles per American gallon). Without alteration, it did 78.26 m.p.h. on Brooklands track. The gear ratio was 2.9:1 and the wheels 35 in. in diameter, so it was a very moderate-speed engine. Several cars with high-speed engines have tried to equal this record and several have done the distance on top gear all right, but the fuel consumption in proportion to the load carried has been far greater.

To beat this combined record of top-gear economy and speed performance would be an advertisement worth many thousands of pounds, but no car with a high-speed engine has so far approached it, although they have the advantage of 21 years' experience of carbureters, ignition, materials and so on. Practically all the really high-price cars here have back-axle ratios of 3 to 3½:1, which is a fairly practical recognition of the advantages of the moderate-speed engine. The moderate-price cars are governed entirely by the necessity for keeping the tax low.

Our Limitations and Possibilities

WE ENGINEERS, it seems, have been interested in our limitations and our latent possibilities. Until recently we have not cared much about the matter. Our jobs were interesting, and we got a big kick out of making nature do our bidding. Then suddenly we awoke to the fact that what we'd been constructing was not merely a lot of skyscrapers, subways, automobiles, radios and airplanes, but a brand new sort of civilization. What's more, while we had been all absorbed in perfecting the parts, a lot of bankers, lawyers and politicians had been trying to run this new civilization and hadn't made a very good job of it. So we began to rub our eyes and inquire, Why can't we run the show ourselves? Then we elected an engineer President, and everyone settled back in comfort, saying that the old economic laws had been adjourned, that we had entered into a new economic era and would all go on being inordinately prosperous for ever and ever. But it's no use blaming our hangover on the President; he was just the unlucky goat. The engineer can have his due, either in public life or in industry, any time he can make good his claim to leadership.

What we want to know is, Are the qualities which in the past have made the engineer successful in mastering nature inconsistent with the qualities which would enable him to master men? Must we choose between the two? Is great constructive ability inconsistent with human leadership?

The engineer of the last century was usually a pioneer of civilization. He had to pierce the wilderness, to wrestle with nature in the rough. He was a builder, who came, surveyed, planned, built, then went his way—a rugged figure, self-reliant, independent to a fault, usually self-made and an individualist to the core. He was not a man of words, his works could speak for themselves. That era has gone. The wilderness has been domesticated. Our population lives in cities. Three-quarters of our people live by industry, commerce and service, rather than by agriculture. The things that concern engineers have to do with organ-

(*Concluded on page* 287)

Council Accepts Four New Sections

TWO SESSIONS of the 1930 and one of the 1931 Council were held during the Annual Meeting. Most of the business transacted was of a routine nature, but a notable step was taken in approving the applications of the Oregon, Pittsburgh, Syracuse and Wichita Sections for recognition as regular Sections of the Society.

Reports of the Standards Committee, as recommended at the meeting of that Committee on Monday morning, January 19, were gone over by the 1930 Council at a meeting held the same day. All the reports were approved as submitted excepting that of the Ball and Roller-Bearings Division. The ball-bearing lock-nuts and washers as recommended by this Division were approved as Recommended Practice up to and including size No. 14. The larger sizes were held in abeyance pending better agreement on the pitch of the thread.

Another meeting of the 1930 Council was held under the chairmanship of President Edward P. Warner on Friday, January 23, to finish the items pending at the close of its administrative year. The financial statement of the Society as of December 31, 1930, showed a balance of assets over liabilities of $242,824.57, this being $2,717.20 less than the corresponding figure at the end of 1929. Gross income of the Society for the first three months of the fiscal year beginning October 1, 1930, amounted to $87,303.42, while the operating expense was $86,086.06.

Applications from the Oregon, Pittsburgh, Syracuse and Wichita Sections for official recognition as Sections of the Society were received; and all four of these, which have up to now been probationary Sections, were formally accepted as regular Sections of the Society.

The schedule of coming meetings was reported upon and discussed, and pending items of membership business were acted upon.

Immediately after the formal adjournment of the last meeting of the 1930 Council on Friday, President Vincent Bendix called a meeting of the 1931 Council. President Bendix announced his appointments on the various administrative committees for the year, and a complete list of all committees of the Society for the ensuing year was received by the Council. These are printed on pp. 269 to 272.

F. K. Glynn, who is vice-president representing Transportation and Maintenance Engineering for 1931, presented his resignation from his office as councilor for 1931-1932. Accordingly, the Council unanimously selected L. Clayton Hill to fill the vacancy for the year.

At the suggestion of the Meetings Committee, the Council approved a plan to hold a National Production Meeting in Milwaukee in cooperation with the Milwaukee Section, and made available an appropriation in connection with it. It is expected that this meeting will be held in April.

President Hoover Speaks

I AM INFORMED that if I were speaking to every person whose livelihood is directly or indirectly dependent upon the industry I should be speaking to one person in every ten of the people of our Country.

Therefore, the prosperity of the industry is in the anxious thoughts of the Nation and everybody wishes you well in your plans to expand the manufacture and use of your product.

The despondency of some people over the future is not borne out by the statistical evidence or prospects in respect to the automobile industry. I am informed by the Department of Commerce that despite the depression you have manufactured and sold during this year, 1930, over 3,500,000 new automobiles. You have also disposed of the large inventories of a year ago.

Hundreds of miles of new roads are being constructed every day in the world and these increasing miles must be equipped with more automobiles.

I am informed, also, that the consumption of gasoline during the last year shows an increase of five per cent over even the highly optimistic year of 1929.

This certainly means that we have been cheerful in the use of our automobiles. I do not assume they are being used for transportation to the poorhouse.

While I am aware that many people are using the old automobile a little longer, it is obvious that they are still using it and that it is being worn out.

Altogether, the future for the industry does not warrant any despondency.

No one needs to recall the utility and importance of the automobile in our national life. I have often wondered, however, if part of its popularity was not due to the exhilarating sense of power that we all inhale through the mastery over time and space we gain from it.

It brings a sense of freedom that makes our spirits rise even though it sometimes invites for some people the depressing ministrations of a motorcycle policeman.

I wish you success in your meeting and in the organization plans which you put forward for the New Year. Every automobile and truck which you make and sell adds to employment in a hundred different trades.

Yours is indeed a great and vital industry, the success of which is important to every one of us. I sincerely wish you a prosperous New Year.

(Address delivered by President Hoover, by telephone from Washington, to executives of the automotive industry assembled at the Annual Banquet of the National Automobile Chamber of Commerce, in New York City, Jan. 6, 1931.)

Commemorative Aeronautic Meeting

SEVEN National organizations, including the Society of Automotive Engineers, will unite in holding a Commemorative Aeronautic Meeting on Feb. 25, starting at 8 p.m., in the Engineering Societies Building, New York City. This meeting has been arranged to commemorate the lives and work of three men who have made outstanding contributions to the art and science of aeronautics. These men are Glenn H. Curtiss, Chance M. Vought and Daniel Guggenheim.

The organizations joining with the S.A.E. in this meeting are the Aeronautical Chamber of Commerce of America, the National Aeronautic Association, the American Institute of Electrical Engineers, the American Institute of Mining & Metallurgical En-

(*Concluded on p.* 286)

SET ASIDE THESE DATES!

APRIL 15 and 16

19th NATIONAL AERONAUTIC MEETING

Book-Cadillac Hotel, Detroit

JUNE 15 to 19

THE SUMMER MEETING

White Sulphur Springs, W. Va.

Personal Notes of the Members

Mead Vice-President of United Aircraft & Transport Corp.

After having served for five years as vice-president of the Pratt & Whitney Aircraft Co., of Hartford, Conn., George J. Mead has been elected vice-president of the United Aircraft & Transport Corp. It is stated that he will have charge of this corporation's newly organized experimental and research division and that his headquarters will be at the company offices at East Hartford.

Mr. Mead was born at Everett, Mass., in 1891 and studied mechanical engineering at the Massachusetts Institute of Technology from 1911 to 1915. Subsequently he became connected with the Simplex Automobile Co., of New Brunswick, N. J., doing experimental work on aviation engines. In 1917 he was appointed experimental engineer with the Wright-Martin Aircraft Corp., of the same city, and in 1919 engineer in charge of the powerplants laboratory of the United States Army Air Service at McCook Field, Dayton, Ohio.

Soon after the Wright Aeronautical Corp. was organized in 1920, Mr. Mead was made chief engineer of that corporation, his work including the development of the Wright E-4, T-3 and J engines. He joined F. B. Rentschler in organizing the Pratt & Whitney Aircraft Co. in 1925, and recently was promoted from his original post of vice-president to the position of chairman of the executive committee, which he still retains. His extensive contribution to the development of the radial air-cooled aeronautic engine is widely recognized.

In 1917 Mr. Mead joined the Society as a Junior Member, and attained Member grade in 1920. His active interest in the Society's work is indicated by his service on numerous committees, as follows: 1921, 1925, 1926 and 1928, member of, and 1922 and 1923 vice-chairman of the Aeronautic Division of the Standards Committee; 1927, House Committee; 1928 and 1929, Aeronautic Safety Committee and Sections Committee; 1929, Aircraft Engineering Division of the Standards Committee, Fuels Subcommittee of Research Committee; 1930, Aircraft-Engine Committee.

Papers contributed by Mr. Mead to the Society, as author or co-author, have been published as follows:

The Requirements of Aeronautic Powerplant Development; THE JOURNAL, July, 1921, p. 23, and TRANSACTIONS, vol. 16, part 2, p. 520.

Airplane-Engine Designing for Reliability; THE JOURNAL, March, 1924, p. 277, and TRANSACTIONS, vol. 19, part 1, p. 695.

Some Aspects of Aircraft-Engine Development, THE JOURNAL, November, 1925, p. 496, and TRANSACTIONS, vol. 20, part 2, p. 809.

The Wasp and Hornet Radial Air-Cooled Aeronautic Engines; THE JOURNAL, December, 1926, p. 609, and TRANSACTIONS, vol. 21, part 2, p. 867.

The Development of Fixed Radial Air-Cooled Engines; S.A.E. JOURNAL, August, 1929, p. 110, and TRANSACTIONS, vol. 24, part 2, p. 418.

GEORGE J. MEAD

Maintenance of Air-Cooled Engines, presented at Metropolitan Section meeting, April, 1929, reported in S.A.E. JOURNAL, May, 1929, p. 543.

In-Line Liquid-Cooled versus Air-Cooled Engines, S.A.E. JOURNAL, August, 1930, p. 143.

Bigelow Succeeds Black

Announcement has been made that Archibald Black has resigned as president of Black & Bigelow, Inc., air-transport engineers of New York City, and been succeeded by A. A. Bigelow, formerly vice-president. Mr. Black's services will, however, continue to be available as consulting engineer to the corporation. The firm name has been changed to A. A. Bigelow & Co., Inc.

Mr. Black was elected to Member grade in the Society in November, 1917. He was born at Inverness, Scotland, in 1888 and supplemented his general education with several courses in evening technical schools. After coming to New York City he was engaged from 1906 to 1912 chiefly in the layout, design and installation of powerplant and sub-station apparatus for the New York Edison Co., the Interborough Rapid Transit Co. and the New York City Railways Co. Successively thereafter he engaged in similar work for the Union Metallic Cartridge Co., of Bridgeport, Conn., and the Detroit Edison Co., until 1916.

Mr. Black first became interested in aeronautics in 1910, and early in 1916 joined the Curtiss Aeroplane & Motor Co., in Buffalo, as engineer draftsman on airplane layout work. Late in the same year he became connected with the staff of the L-W-F Engineering Co., of College Point, N. Y., first as assistant engineer and later chief engineer. During the World War he served as aeronautic mechanical engineer in the aircraft division of the Bureau of Construction and Repair, Navy Department, City of Washington; and in 1919 and 1920 was in charge of aeronautical specifications for the division.

After the armistice, Mr. Black engaged in independent aeronautic consulting engineering in the capital in partnership with his brother under the firm name of A. & D. R. Black, and was one of the founders of the Washington Section of the Society. After termination of this partnership in 1922, he continued his consulting work on aircraft and air transportation up to 1928, when he joined forces with Mr. Bigelow, organizing Black & Bigelow, Inc., and became president and general manager of the new firm.

Mr. Black has been active in committee work for the Society, having been a member of the Aeronautic Division of the Standards Committee in 1918 and 1919 and from 1925 to 1928 inclusive. He was also a member of the Sectional Committee on the Aeronautic Safety Code in 1928 and 1929.

Mr. Bigelow was elected to Member Grade in the Society in August, 1929, at which time he was vice-president of Black & Bigelow. Born at Chicago in 1897, he was graduated from the United States Naval Academy at Annapolis, Md., in the class of 1917, and served in the Navy until 1922, successively as midshipman, ensign and lieutenant. For the next three years he was engaged in non-technical work for the Pacific Mail Steamship Co. and the Munson Steamship Lines. His connection with aeronautics began in 1926, when he was employed by the Colonial Air Transport, in New York City, as traffic manager, his duties including the preparation of cost estimates, traffic surveys and new routes. In 1927 he

(Continued on p. 50)

Applicants Qualified

The following applicants have qualified for admission to the Society between Dec. 10, 1930, and Jan. 10, 1931. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALLEN, R. H. (A) manager, secretary, treasurer, Allen Motor Co., Second Avenue at 10th Street, *Cedar Rapids, Iowa.*

ANDERSON, R. A. (A) chief inspector, Ingersoll Steel & Disc Co., Monmouth Boulevard, *Galesburg, Ill.*

ARNDT, J. W. (A) general manager, secretary, Tidewater Lines, Inc., Sharp and Pratt Streets, *Baltimore.*

BAEYERTZ, FRANK (A) manager, lubricating oil sales, Standard Oil Co. of New Jersey, 15 Washington Street, *Newark, N. J.*

BARD, O. L. (A) corporate secretary, Michigan Tool Co., 7171 East Six Mile Road, *Detroit.*

BAYLEY, G. ROLAND (J) draftsman, Buick Motor Co., *Flint, Mich.* (mail) 1206 Decker Street.

BESAW, EARL WILLIAM (A) president, Firestone Tire & Rubber Co. of Canada, Ltd., Beach Road, *Hamilton, Ontario, Canada.*

BUNCH, CLARE WESLEY (J) engineer, branch manager, Wichita branch office, Pioneer Instrument Co., Inc., Brooklyn, N. Y. (mail) 420 West Douglas Avenue, *Wichita, Kan.*

CARROLL, ELLSWORTH W. (M) chief mechanical engineer, Kalif Corp., *Emeryville, Calif.* (mail) 4069 Hollis Street.

CASSADY, G. H. (J) tire design engineer, United States Rubber Co., Detroit; (mail) 1118 Lake Pointe, *Grosse Pointe Park, Mich.*

COCKLIN, HENRY S. (M) chief engineer, Dornier Co. of America, New York City; (mail) 2724 South 10th Street, *Philadelphia.*

DAVIS, A. F. (J) junior engineer, General Motors Research Corp., *Detroit;* (mail) 8577 Indiana Avenue.

DONOHUE, ROBERT M. (A) president, general manager, Danker & Donohue, Inc., 10 Peabody Street, *Boston.*

DWIGHT, RALPH W. (M) body engineer, Auburn Automobile Co., *Auburn, Ind.* (mail) 718 North Jackson Street.

EVANS, BOB G. N. (M) engineer in charge of research, Bunting Brass & Bronze Co., *Toledo, Ohio.*

FARR, GRAY (J) student, University of Mich., Ann Arbor, Mich. (mail) 3370 Cambridge Road, *Detroit.*

FREUDENBERG, CARL V. (J) layout draftsman, Servel, Inc., *Evansville, Ind.* (mail) 16 East Delware Street.

GARNER, EDWARD E. (A) manager, owner, Ed Garner Auto Shop, 2710 Broadway, *Everett, Wash.*

GORDEN, WALTER L. (M) experimental engineer, Johnson Motor Co., *Waukegan, Ill.* (mail) 47 North Elmwood Avenue.

GRASHORN, KARL GERHARD (A) chassis experimental man, Checker Cab Mfg. Corp., North Pitcher Street, *Kalamazoo, Mich.* (mail) Greenwood Avenue, Route 8.

HANN, WILLIAM E. (M) partner, Harness, Dickey, Pierce & Hann, 7-141 General Motors Building, *Detroit.*

JOHNSON, E. D. (J) experimental engineer, Wagner Electric Corp., St. Louis; (mail) 1438 Claytonia Terrace, *Richmond Heights, Mo.*

JOSLIN, LEON RAY (J) assistant research engineer, Standard Oil Development Co., Linden, N. J. (mail) 533 East Second Avenue, *Roselle, N. J.*

KALLER, JOSEPH J. (J) body draftsman, Packard Motor Car Co., *Detroit;* (mail) 12143 Whithorn Avenue.

KEREKES, EMERY B. (J) engineer, American Gas Turbine Corp., New York City; (mail) care P. E. Meadows, 84-48 Manton Avenue, *Jamaica, L. I., N. Y.*

KURETH, DARWIN R. (J) tool and die maker, Stout Metal Airplane Co., division of Ford Motor Co., Dearborn, Mich. (mail) 15990 Ellsworth Avenue, *Detroit.*

LABRIE LUDGER ELIZÉ (M) designing engineer, Bendix Brake Co., *South Bend, Ind.* (mail) Mar-Main Arms.

LAPP, JOHN (A) district superintendent, automotive equipment, Bloomfield division, Public Service Corp., Newark, N. J. (mail) 426 Rahway Avenue, *Elizabeth, N. J.*

LINDSEY, RICHARD H. (A) chief development engineer, Progressive Motor Devices Corp., 2450 South Michigan Boulevard, *Chicago.*

LUSK, HILTON FRANK (M) professor of engineering in charge of aeronautics, Sacramento Junior College, *Sacramento, Calif.* (mail) 2650 21st Street.

MACFARLAN, MALCOLM SCHORR (J) draftsman, Celotex Co., Marrero, La. (mail) 1537 Leda Street, *New Orleans.*

MARSHALL, BROOKS (J) representative, new devices committee, General Motors Corp., *Detroit;* (mail) 1930 Balmoral Drive.

METCALFE, JOSEPH ARTHUR (A) 83 Byron Street, *East Boston, Mass.*

MILES, ROBERT GEORGE (A) service manager, Price-Dayton, Ltd., 10040 104th Street, *Edmonton, Alberta, Canada.*

MULERT, JUSTUS LOUIS (J) engineer, Gulf Production & Pipe Line Co., *Pittsburgh;* (mail) 842 Washington Road, *South Hills.*

NEUMANN, FERDINAND (M) designer, Fisher Body Corp., *Detroit;* (mail) 5045 Drexel Avenue.

NIBLACK, EMMETT A. (S M) regimental motor officer, United States Army, Sixth Field Artillery Mechanized Force, *Fort Eustis, Va.*

NICHOLS, EDGAR BYRON (M) chief engineer, Brown Instrument Co., Philadelphia; (mail) 19 Colonial Avenue, *Moorestown, N. J.*

NORQUIST, VICTOR C. (M) plant engineer, Butler Mfg. Co., 13th and Eastern, *Kansas City, Mo.*

ODEGAARD, SIGURD (A) draftsman, Miniature Plane Co., 15 Watson Road, *Quincy, Mass.*

OLSON, ALBERT (M) manager, Dill Mfg. Co. of Canada, Ltd., 111 Adelaide Street, West, *Toronto, Ontario, Canada.*

POPPE, E. (F M) works manager, Dennis Bros., Ltd., Guildford, England; (mail) Westfield, Horsham Road, *Shalford West.*

PRATT, WILLIAM L. (A) 1604 Putnam Street, *Detroit.*

RENNELL, HENRY H. (A) secretary, general manager, C. O. Jelliff Mfg. Corp., *Southport, Conn.*

RICHARDS, R. W. (A) manager tire sales, Goodyear Tire & Rubber Co. of Canada, Ltd., *New Toronto, Ontario, Canada.*

ROETING, W. H. (A) owner, Harrisburg Auto Body & Radiator Works, 618 South Cameron Street, *Harrisburg, Pa.*

ROSS, D. A. (M) layout engineer, Willys-Overland, Ltd., *Toronto, Ontario, Canada;* (mail) 921 St. Clair Avenue, West.

SAKIYAMA, JISABURO (M) military assistant engineer, Imperial Japanese Army, 1775 Broadway, *New York City.*

SCHALL, HAROLD L. (M) mathematician, Studebaker Corp., *South Bend, Ind.* (mail) 814 31st Street.

SHOEMAKER, C. E., JR. (J) chief inspector, Command-Aire, Inc., *Little Rock, Ark.* (mail) 2815 Ozark Point.

SMITH, BRUCE (J) assistant chief draftsman, Curtiss-Wright Airplane Co., Travel Air division, *Wichita, Kan.* (mail) 2323 East Kellogg.

TILEY, THOMAS C. (M) supervisor, proving grounds division, Harrison Radiator Corp., Lockport, N. Y. (mail) General Motors Proving Grounds, *Milford, Mich.*

TOMPKINS, ROY (A) shop superintendent, Reliance Machine & Motor Co., 215-225 Sixth Street, *Brandon, Manitoba, Canada.*

TROMEL, FREDERICK C. (J) designer, Stearns Mechanical Laboratory, 15830 South Park Boulevard, Shaker Heights, *Cleveland.*

VAN DEURS, WILLIAM (M) engineering draftsman, Ford Motor Co. engineering laboratory, *Dearborn, Mich.* (mail) 464 Beech Street.

VAN VLIET, CORNELIUS (A) manager, aviation department, N. V. American Petroleum Co., Gebouw Petrolea, 's-Gravenhague, Netherland (mail) 9 Rusthoflaan, *Voorburg, Netherland.*

Commemorative Aeronautic Meeting

(*Concluded from p. 283*)

gineers, the American Society of Civil Engineers and the American Society of Mechanical Engineers.

Three addresses are arranged for on the program. One is an illustrated address on the contributions of Glenn Curtiss to aeronautics, by Frank Russell, former vice-president of the Curtiss Aeroplane & Motor Co., and Capt. John H. Towers, U. S. N., a former associate of Mr. Curtiss. The contributions made by Chance M. Vought will be reviewed by E. E. Wilson, formerly a Commander in the United States Navy and aviation aide to the commander-in-chief of the Battle Fleet. The important and practical encouragement given to the promotion of aviation by Daniel Guggenheim is to be covered in a paper by Admiral H. I. Cone, of the United States Shipping Board.

Col. V. E. Clark is to preside at the meeting. Numerous special guests have been invited to attend, including relatives and friends of the men in whose memory the meeting has been arranged; eminent aeronautic authorities; the presidents of the several cooperating societies; officers of the Army, the Navy and the Coast Guard, and pioneer aviators.

An exhibition of models, structures, instruments and pictures illustrative of the work in aviation done by the three men who have recently passed to their rest is to be arranged in the foyer of the building at 29 West 39th Street at the time of the meeting.

Applicants for Membership

The applications for membership received between Dec. 15, 1930, and Jan. 15, 1931, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BANKS, FRANCIS RODWELL, technical representative, Ethyl Gasoline Corp., Victoria, *London, England.*

BAUER, NORMAN G., draftsman, International Harvester Co., *Fort Wayne, Ind.*

BOTTOMLEY, HERBERT EDWARD, engineer and works manager, Brookes Bros., White Rose Garage, East Parade, *Rhyl, North Wales.*

BOWMAN, LLOYD, draftsman, International Harvester Co., *Fort Wayne, Ind.*

BROWN, A. GEORGE W., automotive engineer, Borden's Farm Products Co., Inc., *New York City.*

BULTINCK, JOSEPH A., draftsman, Studebaker Corp., *South Bend, Ind.*

BYRNE, FRANCIS J., inspector, Naval Air Service, *Lakehurst, N. J.*

COREY, L. A., secretary-treasurer, Northern Engraving & Mfg. Co., *LaCrosse, Wis.*

DOYING, W. A. E., inspecting engineer, The Panama Canal, *Washington, D. C.*

DUDROW, CHARLES W., student of machine design, drafting and automobile design, Wiggins Trade School, *Los Angeles.*

DUMSER, LEO A., chief engineer, Sundstrand Machine Tool Co., *Rockford, Ill.*

EDENQUIST, GUNNAR, designer, Kinner Airplane & Motor Corp., *Glendale, Calif.*

EDWARD, CHARLES KEMP, purchasing agent, Durant Motors of Canada, Ltd., *Toronto, Ontario, Canada.*

FARMER, GEORGE, operating engineer, Illinois Power & Light Corp., *Peoria, Ill.*

FOSTER, CARL B., specification engineer, Chevrolet Motor Co., *Detroit.*

FOWLER, HERBERT E., division manager, Delco Appliance Corp., *Rochester, N. Y.*

GATELY, M. J., assistant to first vice-president and general manager, American Oil Co., *Baltimore.*

GOLIAEFF, D. V., chief engineer, Automobile Works AMO, *Moscow, U. S. S. R.*

GOOSTRAY, JOSEPH, mechanical engineer, Hunt-Spiller Mfg. Corp., *South Boston, Mass.*

GREEN, HERBERT FRANKLIN, aeronautical engineer, New Standard Aircraft Corp., *Paterson, N. J.*

GRIERSON, C. I., president, Transport Oil, Ltd., & D. A. Stuart & Co., Ltd., *Toronto, Ontario, Canada.*

HALL, FRED L., service manager, Bendix Westinghouse Air Brake Co., *Pittsburgh.*

HOPKINS, EDWARD T., time-study and standards engineer, General Motors of Canada, Ltd., *Walkerville, Ontario, Canada.*

HORLE, JOSEPH FREDERICK, manager, Motor Service, *London, England.*

HOUSER, THANE E., inspector, Merz Engineering Co., *Indianapolis.*

KAHLENBERG, ROGER W., engineer, Kahlenberg Bros. Co., *Two Rivers, Wis.*

KARNS, C. B., manager manufacturing plants, Standard Oil Co. of Pennsylvania, *Pittsburgh.*

KEMP, JAMES ALEXANDER, chief draftsman, Maudslay Motor Co., Ltd., *Coventry, England.*

KELLEY, EDWARD H., project engineer, Chevrolet Motor Co., *Detroit.*

KLEIN, JOHN M., chief chemist, American Oil Co., *Baltimore.*

LANE, ALAN SIDNEY, inspector of aircraft, Government of India, Civil Aerodrome, Drigh Road, *Karachi, India.*

LIGNIAN, J. A., foreman Flint experimental department, Chevrolet Motor Co. of Michigan, *Flint, Mich.*

MARSHALL, A. G., technical advisor, Shell Oil Co., *Martinez, Calif.*

MARTIN, GEORGE B., engineer, production development department, Budd Wheel Co., *Detroit.*

MCKEE, S. M. C., lubrication engineer, Nourse Oil Co., *Kansas City, Mo.*

MEAD, W. L., supervisor of equipment, The Pennzoil Co., *Oil City, Pa.*

MERRILL, CLARENCE M., Southern California district manager, Defiance Spark Plug, Inc., *Toledo, Ohio.*

NADLER, CHARLES S., laboratory engineer, Eisemann Magneto Corp., *Brooklyn, N. Y.*

PEED, GARLAND POWELL, JR., stress analysis engineer, Cessna Aircraft Co., *Wichita, Kan.*

PHILLIPS, BERNARD C., specification engineer, Tillotson Mfg. Co., *Toledo, Ohio.*

RAES, FRANK, service manager, General Motors (Australia) Proprietary, Ltd., *Marrickville, New South Wales, Australia.*

ROBINSON, J. ARLEY, superintendent of transportation, Hendler Creamery Co., *Baltimore.*

ROBINSON, WARD M., chief engineer, Mueller Brass Co., *Port Huron, Mich.*

RUTENBER, E. R., research engineer, Waukesha Motor Co., *Waukesha, Wis.*

SAYEGUSA, SADAMU, assistant designer, Tokyo Gas & Electric Engineering Co., Ltd., *Omori, Tokyo, Japan.*

SCOTT, PAUL, vice-president, chief engineer, Scott Welded Products, *Long Island City, N. Y.*

SEARLE, DUDLEY F., manager, owner, Searle Air Brake Co., *Oakland, Calif.*

SMITH, H. B., manager, Detroit office, Multibestos Co., *Walpole, Mass.*

SMITH, JOHN PARKER, patent attorney, 724 First National Bank Building, *Chicago.*

STEELE, ROBERT B., eastern district sales manager, Bohn Aluminum & Brass Corp., *New York City.*

TANNER, WILLIAM F., owner, Arrow Trucking Co., *Baltimore.*

TRANDL, FRANK A., vice-president, The Trandl Corp., *Aurora, Ill.*

WEISS, FREDERIC, owner, Weiss Motor Lines, *Baltimore.*

WELLS, T. A., project engineer, Curtiss Wright Airplane Co., Travel Air Division, *Wichita, Kan.*

WHITE, VERNE S., sales, Pennsylvania Rubber Co., *Jeannette, Pa.*

WITTLINGER, LEONARD M., carbureter engineer, Buick Motor Co., *Flint, Mich.*

Our Limitations and Possibilities

(*Concluded from p.* 282)

ized society. We are team-workers; we have our permanent places in the line and the staff. Most of us are salaried employes, and most of us have administrative work to do.

For an engineer to be able to analyze deeply and design skilfully is good, but it is not enough for this age; the engineer has to organize men and handle money. To do this he must be able to convince, to persuade and, on occasion, to command. He must not only reckon with stresses and elastic limits and microstructures and indexes of hardness, but with men's motives and reactions. He must be able, on occasions when cold logic will not suffice, to put his ideas across by force of personality. This is the difference between the 1930 and the 1830 or the 1880 model.

I have suggested on one or two occasions that it might be well to require every student engineer to pass three special tests before leaving college; one in swimming, one in dancing, and one in speaking. The first would be an index of his bodily efficiency and coordination; the second, an index of his social graces; and the third, an index of his ability to put his ideas across among non-technical men. Our coefficient of practising what we preach out at Case seems to be about 67 per cent. We do require swimming and speaking, and we are actually considering the dancing.

Self-consciousness is the great enemy of personal force. Remember the times when you have outdone yourself; they were the times when you became for the moment oblivious of your existence. Self-obliviousness is a habit that one can cultivate—the earlier, the better. No finer service can be done to young people in their plastic teens than to help them acquire this attitude when under the eye of strangers. Dramatics may be a wonderful help to the shy. Athletic team-work may do the same. All group activities of an expressional sort help to conquer embarrassments and build up confidence. There is a lot to engineering education besides calculus and mechanics. It is just as important to provide the spark that will touch off the student's imagination and his spirit of adventure.—From remarks by President W. E. Wickenden, of the Case School of Applied Science, at the Cleveland Section meeting, Dec. 30, 1930.

Notes and Reviews

AIRCRAFT

Sixteenth Annual Report. Published by the National Advisory Committee for Aeronautics, City of Washington, December, 1930, 66 pp. [A-1]

Among the important factors that have contributed to the progress of aeronautics during the last year may be mentioned: Consistent advance in technical development; greatly extended use of aircraft for passenger transportation; the activities of the Aeronautics Branch of the Department of Commerce in providing improved and enlarged facilities in aid of air navigation, including radio beacons, lighted airways, and intermediate landing-fields; the activities of the Weather Bureau in providing weather-report services along airways; retrenchment and consolidations within the aircraft industry and elimination of surplus organizations resulting in a sounder financial structure for the industry as a whole; enactment by Congress of the Watres bill to promote air mail and passenger carrying; well-organized and equipped laboratories for scientific research; schools for training technical personnel and Federal rating of schools for training student pilots; and, last but not least, the great stabilizing factor, the Army and Navy five-year aircraft procurement programs.

The publications of the National Advisory Committee for Aeronautics are reviewed in these columns from time to time.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor, *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

Pressure Distribution over a Symmetrical Airfoil Section with Trailing-Edge Flap. By Eastman N. Jacobs and Robert M. Pinkerton. Report No. 360. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930. [A-1]

Measurements were made in the variable-density wind-tunnel of the National Advisory Committee for Aeronautics to determine the distribution of pressure over one section of an R.A.F. 30 (symmetrical) airfoil with trailing-edge flaps. To study the effect of scale, measurements were made with air densities of approximately 1 and 20 atmospheres.

Isometric diagrams of pressure distribution are given to show the effect of change in incidence, flap displacement and scale upon the distribution. Plots of normal force coefficient versus angle of attack for different flap displacements are given to show the effect of a displaced flap. Finally, plots are given of both the experimental and theoretical characteristic coefficients versus flap angle, in order to provide a comparison with the theory. The conclusion is that for small flap-displacements the agreement for the pitching and hinge moments is such that it warrants the use of the theoretical parameters. However, the agreement for the lift is not as good, particularly for the smaller flaps. In an appendix, an example is given of the calculation, from these parameters, of the load and moments on an airfoil with hinged flap.

Experimental Determination of Jet Boundary Corrections for Airfoil Tests in Four Open Wind-Tunnel Jets of Different Shapes. By Montgomery Knight and Thomas A. Harris. Report No. 361. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930. [A-1]

This experimental investigation was conducted primarily for the purpose of obtaining a method of correcting to free-air conditions the results of airfoil force tests in four open wind-tunnel jets of different shapes. Tests were also made to determine whether the jet boundries had any appreciable effect on the pitching moments of a complete airplane model. The investigation was conducted in the atmospheric wind-tunnel of the Langley Memorial Aeronautical Laboratory.

The method of obtaining the airfoil corrections utilized the results of force tests made in each jet on three similar monoplane airfoil set-ups of different sizes. The data from the tests in one of the jets, which was circular, were extrapolated to the condition of infinite air space, and the results were found to agree with those obtained by means of Prandtl's theoretical method of correction. On this basis corrections were obtained for all the other airfoil tests.

Satisfactory corrections for the effect of the boundaries of the various jets were obtained for all the airfoils tested, the span of the largest being 0.75 of the jet width. The corrections for angle of attack were, in general, larger than those for drag The boundaries had no appreciable effect on the pitching moments of either the airfoils or the complete airplane model. Increasing turbulence appeared to increase the minimum drag and maximum lift and to decrease the pitching moment.

Bending Tests of Metal Monocoque Fuselage Construction. By Ralph W. Mossman and Russell G. Robinson. Technical Note No. 357. [A-1]

Experiments with a Model Water-Tunnel. By Eastman N. Jacobs and Ira H. Abbott. Technical Note No. 358. [A-1]

A Balanced Diaphragm Type of Maximum-Pressure Indicator. By J. A. Spanogle and John H. Collins, Jr. Technical Note No. 359. [A-1]

The foregoing Technical Notes were issued during November and December, 1930, by the National Advisory Committee for Aeronautics, City of Washington.

Riveted Joints in Thin Plates. By W. Hilbes. Translated from Jahrbuch 1929 der Wissenschaftlichen Gesellschaft für Luftfahrt. Technical Memorandum No. 590, 15 pp., 9 figs. [A-1]

Mathematical Treatise on the Recovery from a Flat Spin. By R. Fuchs. Translated from Jahrbuch 1929 der Wissenschaftlichen Gesellschaft für Luftfahrt. Technical Memorandum No. 591, 16 pp., 5 figs. [A-1]

Metal Covering of Airplanes. By J. Mathar. Translated from Jahrbuch 1929 der Wissenschaftlichen Gesellschaft für Luftfahrt. Technical Memorandum No. 592, 15 pp., 19 figs. [A-1]

Practical Tests with the Auto Control Slot. By G. Lachmann. Part I: Lecture, Technical Memorandum No. 593, 20 pp., 20 figs. Part II: Discussion, Technical Memorandum No. 594, 30 pp., 36 figs. Translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Sept. 15, 1930.

English Airplane Construction. By D. Schwencke. Translated from *Zeitschrift des Vereines deutscher Ingenieure*, August, 1930. Technical Memorandum No. 595, 11 pp., 32 figs. [A-1]

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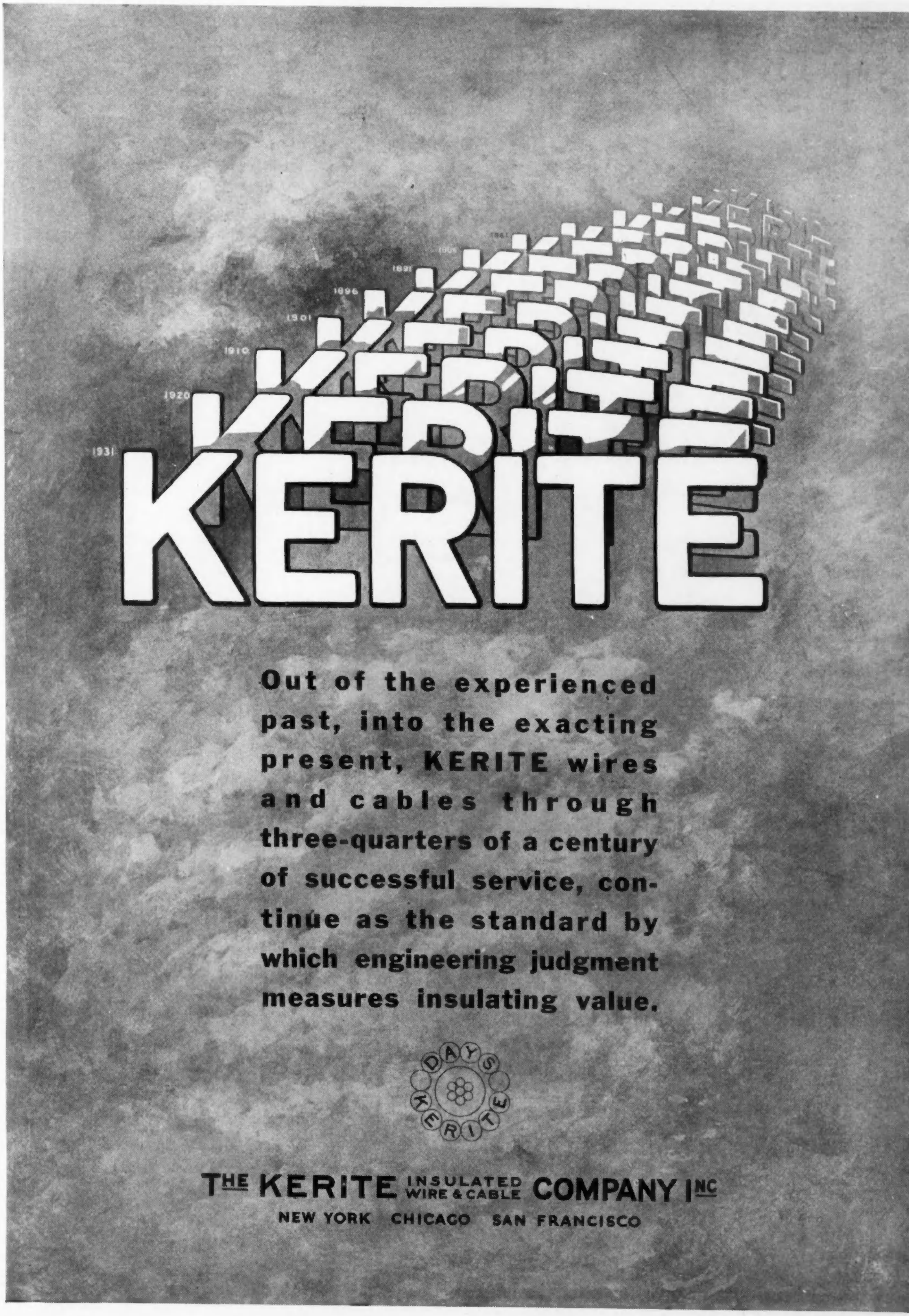
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Notes and Reviews

Continued

Riveting in Metal Airplane Construction, Part I. By Wilhelm Pleines. Translated from *Luftfahrtforschung*, vol. VII, No. 1, April 30, 1930. Technical Memorandum No. 596, 42 pp., 35 figs. [A-1]

Riveting in Metal Airplane Construction, Part II. By Wilhelm Pleines. Translated from *Luftfahrtforschung*, vol. VII, No. 1, April 30, 1930. Technical Memorandum No. 597, 50 pp., 23 figs. [A-1]

Riveting in Metal Airplane Construction, Part III. By Wilhelm Pleines. Translated from *Luftfahrtforschung*, vol. VII, No. 1, April 30, 1930. Technical Memorandum No. 598, 28 pp., 27 figs. [A-1]

Riveting in Metal Airplane Construction, Part IV. By Wilhelm Pleines. Translated from *Luftfahrtforschung*, vol. VII, No. 1, April 30, 1930. Technical Memorandum No. 599, 32 pp., 27 figs. [A-1]

The foregoing Technical Memoranda were issued during November and December, 1930, by the National Advisory Committee for Aeronautics, City of Washington.

Gliders and Gliding. By Lieut. Ralph Stanton Barnaby. Published by the Ronald Press Co., New York City, 1930, 170 pp. Price $3. [A-1]

This book tells by word and by drawing everything one could wish to know about gliders and gliding: their operation, design principles and construction features. It is organized to give a complete course in gliding, from preliminary instruction, primary hops, secondary extended glides and maneuvers to soaring, the ultimate goal of the glider fan. Those in a position to safely build their own gliders are given the needed details concerning design and construction, with special emphasis on materials and aerodynamic safety.

Lieutenant Barnaby is head of the specification section of the United States Navy Bureau of Aeronautics, City of Washington. He has been a member of the S.A.E. since 1917 and is an active member of the Aviation Division of the Standards Committee.

Ice Formation on Aircraft and Its Prevention. By Merit Scott. Reprint from *The Journal of the Franklin Institute*, vol. 210, no. 5, November, 1930. [A-1]

The work reported herein was done in the Department of Physics at Cornell University under the direction of the Committee on Aeronautics and was supported by a grant from the Daniel Guggenheim Fund for the Promotion of Aeronautics.

The conclusion from this study is that the heat dissipated by the airplane engine is sufficient for the prevention of ice formation upon the important exposed parts of a monoplane. The heat of the exhaust gases or of vapor, if the latter method is used, may be absorbed by ducts integral with the leading edges of the wing and tail surfaces and distributed by them in an effective manner to the surfaces of these parts. At least in the cases of using the exhaust gases, the propeller may also be protected from ice formation. This can be accomplished by conducting the hot gases to the interior of a hollow metallic propeller by a sliding valve and allowing it to discharge from exit ports near the propeller tips.

Marine Aircraft. By P. H. Sumner. Published by Crosby Lockwood & Son, London, 1930, 196 pp. Price, 16 shillings. [A-1]

Captain Sumner is a well-known authority on aeronautics and is the author of several books. His articles, published in various British publications, have been reviewed from time to time in the S.A.E. JOURNAL.

The first chapter of the present book, which covers 97 pages, is an excellent introduction to the flying-boat world. It is amply illustrated. The following chapters explain the conditions required for the air-borne condition of the boat

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Continued

seaplane; displacement, buoyancy, and stability problems; materials, and systems of construction and construction members.

All this is followed by a very interesting and useful appendix.

The Attempted Take-Off of the "City of Tacoma" for the Trans-Pacific Flight at Kasumigaura, Japan. By Taitiro Ogawa. Report No. 63 of the Aeronautical Research Institute, Tokyo Imperial University, October, 1930, 8 pp., 4 figs. **[A-1]**

The motion and the attitude of the City of Tacoma during the unsuccessful start for the trans-Pacific flight from Kasumigaura on Aug. 30, 1930, were measured photogrammetrically.

The fuel was discharged through the emergency valves 89 sec. after the start, the distance of 1557 meters having been run of the total runway of 1900 meters, and the velocity of 125 km. per hr. having been attained. With this velocity, the "unstick" would have been possible, if the lift coefficient of the wing had been over 1.42. As the airplane actually took off the ground in only 0.6 sec. after the commencement of the discharge, the lift coefficient might well be assumed very close to this value.

The tail did not rise throughout the failed take-off run except the bouncing probably caused by some obstacles on the runway. If the center of gravity were situated farther forward to raise the tail easier, or if a tail wheel or tail carriage, which can be left on the ground, had been adopted, the ground friction would have been much reduced and the take-off might have been more possible.

On the Acoustical Properties of Conical Horns, Part II. By Kozi Sato. Report No. 64, of the Aeronautical Research Institute, Tokyo Imperial University, November, 1930, 23 pp. **[A-1]**

The sound field due to a conical horn with a simple source at its vertex was calculated. If the origin is taken at the vertex of the cone and the polar axis on its axis, the velocity potential at any point external to the horn is given. The kinetic and potential energies have different values in general, but at an infinite distance from the source they become equal and are inversely proportional to the square of the distance, as in the case of a spherical wave.

The theory started with the assumption that, on the spherical surface containing the opening of the conical horn, the motion of air exists in its opening only.

From the comparison of the results of this theory with actual measurements, the author infers the correctness of the theory and the applicability of the reciprocal theorem.

The Airplane. By Frederick Bedell. Published by D. Van Nostrand Co., Inc., New York City, 1930, 371 pp. Price, $3. **[A-1]**

The first 13 chapters of this practical discussion of the principles of airplane flight comprise material that has appeared in earlier editions, but the material for the last five chapters appears for the first time and completes the plan of the author to present a well-rounded treatment of the airplane, covering the general principles of airplane flight in a way that is simple and at the same time reasonably complete and accurate.

In this edition a full discussion of the airplane engine and its latest developments is included; also an analysis of the air propeller, with the description of various types of airplane. A comprehensive chapter on airplane instruments shows some of the problems that confront the pilot, and a chapter on outstanding problems indicates the present line of development of the art of airplane flight.

Aircraft-Propeller Design. By Fred. E. Weick. Published by the McGraw-Hill Book Co., Inc., New York City, 1930, 294 pp. Price, $4. **[A-1]**

The author is aeronautical engineer at the Langley

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Notes and Reviews

Continued

Memorial Laboratory of the National Advisory Committee for Aeronautics and a member of the S.A.E. He has incorporated in this book his experiences of several years in experimenting with and designing propellers. The important experimental, theoretical and practical developments are considered not only from the point of view of propeller performance and efficiency but also directly in terms of the effect on airplane performance. The work is amply illustrated with charts and photographs.

Comparaison entre les Dirigeables et les Avions. By Max Verneuil. Published in *Le Génie Civil*, Nov. 29, 1930, p. 538. **[A-1]**

Is the public justified in its distrust of lighter-than-air craft, brought on by the series of airship catastrophes? Should France continue to maintain its policy of not building large airships? Other countries have maintained their interest in this type of craft, and Germany has been notably successful in creating in the large dirigible a tool well adapted to commercial use over long distances. The R-101 disaster should not enter seriously into the controversy between lighter and heavier-than-air craft, since this ship was defective in construction.

After these preliminary remarks, the author enters into the main subject matter of his article, a comparison between the airship and the airplane. The following points are chosen as the basis of the comparison: regularity and speed of the trips, length of trip and amount of useful load, operating conditions, possibilities for improvement, efficiency and costs.

The author emphasizes in his conclusion the thought that partisans of either type should not regard their choice as supreme but should work together to perfect regular commercial utilization of air routes.

Uber die Bestimmung von Widerstand und Trimmoment bei Gleitenden Wasserfahrzeugen. By P. Schröder. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Nov. 28, 1930, p. 577. **[A-1]**

The Hamburg institute for marine research deals in this publication with the resistance and trimming moment of hydroplanes. Formulas are developed for determining these two factors first for hydroplanes, then for such structures as are used for pontoons for aircraft, and, finally, for deriving these values for pontoons applied to different aircraft from results already obtained for a given case.

The analytical methods are graphically presented, and then examples are worked out in which the methods are applied and the results obtained checked by measurements. Examples include a hydroplane, a pair of pontoons, the effect of varying the gross weight of the aircraft, and the effect of wind upon the take-off of seaplanes.

Die Statische Längsstabilität der Entenbauart. By Heinrich Georg Kiel. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Dec. 15, 1930, p. 601. **[A-1]**

The type of airplane construction in which the horizontal control surfaces are forward of the wings instead of at the rear is the subject of this article. Several advantages are claimed for the less conventional design, such as great total lift for the same wing and tail surface, and greater safety from stalling. However, difficulties present themselves in securing static stability, and the author proposes in this article to investigate specifically static longitudinal stability.

In the more theoretical section of the article, the derivation of formulas affecting stability is traced, wing, horizontal and tail surfaces being considered separately. The conditions that must be satisfied for the securing of stability are set forth and the influence of wing profile on stability investigated.

Following this exposition of fundamentals, the formulas derived are applied in the examination of the characteristics of two wing-profiles to judge of their suitability for the

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Continued

unconventional construction under discussion. The conclusion is drawn that profile shape is of overwhelming importance in the static stability of the structure, and rules for securing such stability are set forth.

Utilisation des Procédés Loth pour la Navigation Aérienne. By A. Verdurand and J. Blancard. Published in *L'Aéronautique*, October, 1930, p. 363. [A-1]

The two sections comprising this article are respectively a critical study and a defense of the Loth methods for guiding aircraft by the use of Hertzian waves. The basis of the treatise is the operation of a small-scale model of the apparatus now being demonstrated at Vaux-sur-Seine. In summing up the arguments presented for and against these methods, the editor points out that proponent and opponent agree as to the actual functioning of the methods developed, but differ in their opinions as to the facility with which these phenomena may be adapted to aerial navigation.

For guiding an aircraft along a chosen route, two revolving beacons are provided, one of which emits long signals or dashes, and the other short signals or dots, so timed that the sending of the dash commences just as the dot is completed. The beacons are turned so that their sending axes constantly cross on the route that the airplane must follow. Theoretically, the receiving set on the airplane will record a continuous sound, made up of an uninterrupted series of dots and dashes, so long as the correct route is being followed, but when there is any deviation only dots or only dashes will be heard, depending on whether the airplane has strayed to the right or the left of the course.

The criticisms made are that in operation the signals heard are not so simple as the theory indicates, but need judicious interpretation; that the range of practical utilization of Hertzian waves is limited; and that, even if perfected, the Loth system could be applied to only a few major routes.

The apparatus for guiding the airplane in the vicinity of the airport includes two circular aerial cables. These, according to the critic, themselves constitute a danger. Moreover, there are certain zones in which the signals are doubtful, the receiving apparatus must be adjusted with minute care, and the pilot receives no warning of his close approach to the ground until he is too near to be benefited by it.

The Causes of Noise in Aircraft. By A. H. Davis, D.Sc. Published in *Aircraft Engineering*, November, 1930, p. 273. [A-4]

The high record for safety, directness and speed of aircraft contributes to the increasing popularity of air travel. Many persons, however, object to the discomfort caused by the noise experienced.

The principal sources of noise in aircraft are clearly the exhaust, the airscrew, and vibration communicated to panels of the cabin structure by vibrations set up by the engine or, to a less extent, by vibrating stay-wires. Remedies and palliatives for these are suggested.

The quieter airplanes in use today differ from the noisier ones in the reduced airscrew-speed; more favorable position of engines, airscrews and exhausts; or in the provision of more substantial cabin walls. So far no individual machine seems to incorporate all the chief improvements possible.

CHASSIS PARTS

Some Experiments on the Factors Affecting the Motion of a Four-Wheeled Vehicle When Some of Its Wheels Are Locked. By J. Bradley, B.A., and S. A. Wood, M.Sc. Published by the Institute of Automobile Engineers, London, 1930, 19 pp. [C-1]

The points studied and discussed are: weight distribution on the wheels; height of center of gravity; moment of inertia about a vertical axis through the center of gravity; and arrangement of brakes.

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The experiments were made on a model. The results given are averages of several observations in good agreement. It was found that four-wheel brakes give the shortest stopping distance, coupled with very little tendency for rotation about the center of gravity. When the center of gravity is approximately central, front-wheel locking exerts a greater retarding force than rear-wheel locking; in addition, a straight path is followed with locked front wheels, as against an extremely uncertain path with rear brakes alone. Any combination of brakes unsymmetrical about the center-line of the vehicle leads to deviation from the initial direction. These results are ably discussed and amply illustrated by mathematical deductions, tables and charts.

Factors Affecting the Behavior of Rubber-Tired Wheels on Road Surfaces. By J. Bradley, B.A., and R. F. Allen, B.Sc. Published by The Institute of Automobile Engineers, London, 1930. 22 pp. [C-1]

The experiments discussed in this paper were undertaken to compare the relative slipperiness of road surfaces and to determine the factors which are conducive to the skidding of vehicles on such surfaces. It should interest alike the highway engineer, the tire manufacturer and the vehicle designer.

There are two distinct forms of slipping on road surfaces; the first occurs when brakes of a moving vehicle are applied with sufficient force to lock the wheels; the second occurs on curves or on steeply cambered surfaces when the wheels continue to revolve but slip at right-angles to the direction of rolling.

The surfaces studied were waterbound macadam, tarred macadam, wood blocks, asphalt, concrete, mastic asphalt, and asphaltic concrete. The experiments were made under dry, wet, slightly wet and muddy conditions.

The authors concluded that experiments made at low speeds have very little value in measuring the slipperiness of road surfaces. Some of these surfaces show an increase of slipperiness with increase of speed. Increase of slipperiness with speed depends not only on the state of the road surface but also on the tire. Badly worn treads and large contact areas should be avoided. It is best not to make the tread of a tire continuous but to break up the contact area into a number of disconnected pieces. Some of the road surfaces studied show little or no variation with weather conditions, speed or form of tire.

EDUCATION

Principles of Engineering Thermodynamics. By Paul J. Kiefer and Milton C. Stuart. Published by John Wiley & Sons, Inc., New York City, 1930. 545 pp. Price $4.50.

This textbook is divided into five parts. Part I considers the First Law of Thermodynamics, with particular emphasis on an understanding of the distinctive characteristics of the several stored and transient forms of energy and of the energy equation as it applies to the innumerable steady-flow machines which are encountered in engineering practice. Part II considers the Second Law and the Carnot Principle, with emphasis on the availability of energy and the associated physical significance of the entropy function as an index on the unavailability of energy. Part III describes the physical properties of the vapors and gases and their mixtures. Part IV utilizes the principles and methods of the preceding parts in analyses of motive-power machinery and certain power-using apparatus. Part V develops the general Thermodynamic Equations. A summarizing article epitomizes the essential features at the end of each chapter.

ENGINES

Modern High-Speed Ignition. By Frank E. Tenney. Published by the Goodheart-Willcox Co., Inc. Chicago, 1930, 123 pp. [E-1]

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For the last 10 years the author has been teaching the subject of self-starting, lighting and ignition at the Franklin Union Institute, Boston. The first section of the book is devoted to the general subject of automobile ignition and the reasons for developing present-day twin and dual ignition systems. The second section is devoted to full and complete operating instructions for every make, model and type of synchronizing tool, breaker gage and special synchronizing apparatus found in general use today.

Exhaust Ports and Maximum R.P.M. of High-Speed Two-Stroke Oil Engines. (Luci di scarico e limiti di giri nei motori Diesel veloci a due tempi.) By P. C. Lombardo. Published in *L'Industria,* July 31, 1930, p. 376. **[E-1]**

Considerable research upon the Diesel engine, carried out in the laboratories of engine manufacturers and National research establishments, has brought to light the fact that this type of engine is capable of very high speed. A speed of from 2000 to 2500 r.p.m. has been obtained from tests.

The author feels that the two-stroke Diesel engine will solve the problem of weight and speed, provided the necessary perfection is evolved in the lubricating system.

As a solution of the problem, he gives a tentative method of determining the dimensions of the exhaust ports and arrives at a formula. Diagrams of the exhaust ports of the two-stroke engine of the Clerk type and of the Junker engine are discussed in detail.

The interdependence of the port areas and the revolutions per minute and the influence of manufacturers on these are duly considered.

With the cooperation of the manufacturers, the author feels that, for the two-stroke Diesel engine, all other conditions being equal, a theory of doubling the power with the same cylinder capacity can be developed.

The Plating on Radiator Shells. By Oliver P. Watts. Paper presented at 58th general meeting of American Electrochemical Society, Detroit, Sept. 25 to 27, 1930. **[E-1]**

Since the plating most seen by the public is that on automobiles, the author, anxious to contribute to the improvement of the plating on automobiles, shows exactly what results are produced by current methods of plating.

Photographs of the plating on radiator shells are shown, accompanied by a description of the preparation of the steel and the details of plating. Heavy electrodeposits on steel are prescribed, to insure lasting protection against corrosion. The proper preparation of the steel surface preliminary to plating is an important factor. The actual thickness of various copper, nickel and chromium deposits was determined microscopically. Tests were made for pinholes and cracks in the plates. Finally, samples were immersed in a 35 gram per liter NaCl solution. Many specimens were in good condition after 23 days' immersion.

A Simple Method for the Calculation of Natural Frequencies of Torsional Vibration. By Frederic P. Porter. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Dec. 1 to 5, 1930. **[E-1]**

The calculation of the torsional-vibration characteristics of the shafting of reciprocating-engine installations is generally regarded as a laborious undertaking. This paper presents a method for calculating the natural frequencies of the shafting that is relatively simple in its application and yet retains the accuracy of the longer methods. This simplification is obtained by the correct choice of the equivalent system for mathematical treatment and by the use of tables and charts. The accuracy of the results has been compared with that of the results of other investigators.

An Investigation of the Effectiveness of Ignition Sparks. By Melville F. Peters, Wayne L. Summerville and Merlin Davis. Report No. 359. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930. **[E-1]**

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The effectiveness of ignition sparks was determined by measuring the volume (or mass) of hydrogen and oxygen which combines at low pressures. The sparks were generated by a magneto and an ignition spark-coil. It was found that, with constant energy, the amount of reaction increases as the capacitance component of the spark increases. The use of a series spark-gap may decrease or increase the amount of reaction, the effect depending upon the amount and the distribution of capacitance in the circuit. So far as the work has progressed, it has been found that sparks reported by the other investigators as being most efficient for igniting lean mixtures cause the largest amount of reaction. Differences between the amount of reaction with a magneto spark and an ignition spark-coil were noted. The method appears to offer a means of determining the most efficient spark generator for internal-combustion engines as well as determining a relation between the character of spark, energy and effectiveness in igniting inflammable mixtures.

The Present Position of the High-Speed Heavy-Oil Engine. By S. J. Davies and E. Giffen. Published in *Engineering*, Oct. 24, 1920, p. 532. **[E-1]**

The engines used in this study are limited to those in which the fuel is injected in liquid form into the combustion space, and with operating speeds exceeding 800 r.p.m. The conclusions were that the heavy-oil engine made possible a higher ratio of expansion than the gasoline engine. There was a marked saving in the fuel cost, and the heavy oil occupies less volume than an equal weight of gasoline.

The practical elimination of fire risk by the higher flash-points of heavy oil and the comparative purity of the exhaust gas are advantages in favor of the heavy-oil engine. It also sustains its torque much better than the gasoline engine at low speed.

Twenty-eight different designs were studied and the results tabulated. The different types of combustion-chambers are sketched. Different types of nozzles and pumps are illustrated and described.

The study revealed an extraordinary variety in engine designs. It is expected that when standardization sets in the number will be greatly reduced.

Kolben im Kraftfahrzeugbau. By Ernst Mahle. Published by *Deutsche Motor-Zeitschrift*, Dresden, Germany, 17 pp.; 36 figs. **[E-1]**

In this comprehensive review of the present state of piston design and construction, the author first outlines the functions that the piston must perform and emphasizes their difficulty. Piston material, he states, must possess three essential properties: light weight; good operating characteristics, such as resistance to wear and heat and a low coefficient of thermal expansion; and high heat-conductivity. He examines the metals most commonly proposed for piston material—cast iron, aluminum and magnesium—as to their ability to meet these requirements and concludes that special aluminum alloys are most successful in all respects. The increasing proportion of aluminum-alloy pistons in both Europe and this Country is cited as a proof of this contention.

Different types of piston construction are next reviewed. While cast-iron pistons have been improved considerably during the last 10 years, such developments are said to be of little importance, since cast-iron pistons are so little used. Magnesium pistons are dismissed with a few words, as they are reserved for only very special applications. Types of aluminum-alloy pistons discussed include the normal conventional construction, the split-skirt piston, pistons made of alloys with low coefficients of thermal expansion, and invar-strut pistons. Reference is made to numerous patents that have not been successful commercially and to other parts and functions closely associated

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with piston performance, such as the cylinder, piston rings and pins and lubrication.

Kolbenspiel für Fahrzeugmotoren. By Ernst Mahle. Published by *Das Kraftfahrzeug-Handwerk*, Berlin. 6 pp.; 14 figs. [E-1]

The simple rules for clearance between two parts, one of which runs within the other, cannot be applied in the case of cylinders and pistons, the author points out in this article on piston clearance, because of the effect of operating temperatures on both parts. He shows how this factor can be provided for, giving, for different types of piston, operating temperatures in water-cooled engines, coefficients of thermal expansion, the expansion of pistons and cylinders of various diameters and, finally, the theoretical tolerance required. He applies these theoretical considerations to cast-iron, aluminum-alloy, split-skirt and invar-strut pistons, drawing conclusions favorable to the last-named.

Der Cas-Rohölmotor. By Karl Fr. Nägele. Published in *Automobiltechnische Zeitschrift*, Dec. 20, 1930, p. 848. [E-1]

The brilliant success of the high-speed, high-compression oil engine should not blind the engineer to the merits of the low-pressure heavy-fuel powerplant, asserts the author. The latter type of engine is said to have for its field of usefulness that of stationary powerplant and of tractor propulsion. The necessary characteristics are small size, light weight and cheapness of manufacture and operation.

Dismissing with a few words the adaptation of the conventional carbureter engine for crude-oil use, the author turns to the two-stroke cycle as the more promising development. He describes two such engines, one incorporating fuel-injection into the crankcase, the other fuel-injection into the transfer port, and points out a number of disadvantages which impair their usefulness. Finally, he takes up the single-cylinder experimental Cas engine, in which fuel is injected directly into the cylinder. Provisions are made in this engine for heating the fuel charge, atomizing it and for furthering combustion through turbulence. Good performance, easy regulation, flexibility and the ability to burn any type of fuel are among the advantages claimed.

Aviation Engine Examiner. By Major Victor W. Pagé. Published by the Norman W. Henley Publishing Co., New York City, 1930, 448 pp. Price, $3. [E-2]

The simple and direct language, together with the question and answer method of subject presentation, should make this a valuable book to persons desiring elementary information concerning modern aviation engines of all types and sizes and their accessories.

For those desiring to qualify for aircraft mechanics, it is a systematic course of lessons that may be studied at home or at school. Many fine points of engine design and construction are discussed. The questions of construction and repair, engine timing, engine parts, carburetion and fuel systems, cooling, lubrication, and ignition systems of various engines are carefully considered.

The illustrations are numerous and exceptionally clear in details.

Motor-Vehicles and Their Engines. By Fraser and Jones. Published by D. Van Nostrand Co., Inc., New York City, 1930, 411 pp. Price, $3. [E-3]

The material for this fourth edition was revised by Lee A. Dunbar, assisted by E. B. Neil, of the Chilton Class Journal Co., and A. C. Woodbury, of the editorial staff of the S.A.E.

The old material has been thoroughly modernized and a wealth of new matter descriptive of the many recent mechanical improvements that have been perfected since 1926 is introduced.

The generous reception accorded the earlier editions of the textbook for automobile schools shows that it has met with the approval of teachers and students.

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MATERIAL

Copper Brazing in Hydrogen-Electric Furnaces. By H. M. Webber. Paper presented at the 12th annual convention of the American Society for Steel Treating, Chicago, Sept. 22 to 26, 1930. **[G-1]**

In this paper the author discusses the copper-brazing process utilizing electric furnaces with hydrogen atmospheres, as developed and applied by the laboratory and factory staffs of the General Electric Co. An explanation is given for the ready flow of molten copper into tight steel joints, the statement being made that results obtained with the process improve as contact pressures increase. Considerable strength is obtained, as well as gas tightness, because of (*a*) the ability of copper to wet and flow on iron, (*b*) the available capillary force, (*c*) the formation of metallic solutions and (*d*) the tendency toward grain growth across the joints.

The discussion touches upon effects of the relatively high furnace-temperatures required and the effects of the hydrogen atmosphere upon steel. Some applications of the process are cited, followed by references to furnace design and apparatus for producing the gases required for furnace atmospheres.

Relation of Structure to Surface Hardness of a Case-Hardened Steel. By H. W. McQuaid and O. W. McMullan. Paper presented at the 12th annual convention of the American Society for Steel Treating, Chicago, Sept. 22 to 26, 1930. **[G-1]**

Hardness specifications are generally intended to result in the production on the part being hardened of a surface that will give in service the longest life in the most economical manner. The great variation of surface requirements met with in the automotive industry makes very difficult the specifying of a certain hardness by any particular measuring device with certainty that the hardened surface will be the most satisfactory for the use intended. Thus, the surface that must be obtained on highly stressed gears, bearings and the like, where resistance to abrasion and exceedingly high unit-pressures are met with, should be different than the surface required on a worm or piston-pin, where the unit pressures are relatively low and the most important requirement is resistance to wear caused by sliding friction. On parts such as the automotive worm, the surface should be as hard as possible, to resist wear, and it is not necessary, as a rule, to give special concern to obtaining ductility at the sacrifice of surface hardness. On parts that must resist considerable battering, the austenitic structure such as is obtained with the Hadfield analysis, has been found almost impossible to improve upon. It is quite possible in many cases where an extremely high scleroscope or Rockwell reading is specified, that the softer austenitic surface, which is file hard, would give much better results in service. At least this is indicated by the results obtained with pot-quenched case-hardened alloy drive-pinions.

The authors believe that the maximum amount of excess carbides in a case, together with the maximum Rockwell and scleroscope hardness, gives the maximum resistance to pure abrasive wear, and that this condition is most satisfactory for worm and similar surfaces.

Stresses and Cracks in Hardened and Ground Steel. By Gerald R. Brophy. Paper presented at the 12th annual convention of the American Society for Steel Treating, Chicago, Sept. 22 to 26, 1930. **[G-1]**

The work described in this paper deals with stresses introduced in hard steel surfaces by grinding and the detection and classification of these stresses.

Pickling causes the stressed areas to crack, and acids of different concentrations pick out the high and low stresses. The time in the bath is also a measure of stress. Low

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stresses require a stronger acid or a longer time in a given acid than do high stresses. The influence of heat-treatment is also discussed.

Other papers presented at the A. S. S. T. convention that may be of interest to the automotive engineer are: Scaling of Steel at Forging Temperatures, by W. E. Jominy and D. W. Murphy; Influence of Nickel on the Chromium-Iron-Carbon Constitutional Diagram, by V. N. Krivobok and M. A. Grossmann; and Corrosion Test for Research and Inspection of Alloys, by William R. Huey.

Engineering Factors Involved in the Replacement of Metals by Synthetic Resins—Phenol-Resinol Molding Technique. By Leon V. Quigley. Paper presented at the Fourth National machine-shop-practice meeting of the American Society of Mechanical Engineers, Chicago, Sept. 22 to 24, 1930. [G-1]

In this paper an effort has been made to show the origin, comparative properties and present industrial position of phenol-resinol material. This resinoid class of substance, which is a product of the research laboratory, has been regarded as a major class among materials of construction. It has been ranked with wood, stone and metal, its unusual combination of properties adapting it to every field of engineering. Its thousands of important industrial applications create new departments in mechanical shop practice. Effort has been made to indicate and to discuss the engineering factors that govern its adoption in new fields.

L'Unification Mondiale des Methodes de Discrimination des Combustibles Liquides pour Moteurs. By A. Grebel. Published in *Le Génie Civil*, Dec. 6, 1930, p. 557. [G-1]

Before any real progress can be made in the world-wide economic utilization of petroleum, some systematic standardization must be introduced into methods of dealing with fuel problems. At present even the names by which different types of fuel are known vary from country to country, and much confusion can be traced to this obscure terminology. With the increase in the different types of petroleum field being worked and in the processes of refining, the finished products become more widely differentiated from one another. In the present article a plea is made for the standardization of tests for determining those properties of liquid motor fuels that may serve for identification purposes.

The characteristics which the author considers must be included in any such series of identification tests are gravity, volatility, viscosity, flash-point, spontaneous ignition temperature, specific thermal capacity, iodine index and sulphur content. He reviews apparatus developed for determining these properties, makes reference to other characteristics and gives reasons for not including these in his original list. He devotes some space to detonation characteristics, stating that no standard method has been developed so far and emphasizing the difficulty of designing a standard test engine.

Repair of Worn Parts by Electrodeposition of Iron. By T. P. Thomas. Paper presented at the Fourth National machine-shop-practice meeting of the American Society of Mechanical Engineers, Chicago, Sept. 22 to 24, 1930. [G-2]

A commercial method is described for salvaging worn or undersized steel parts, such as thread and plug gages, arbors, reamers, motor shafts and gear centers, by the electrodeposition of iron. Details of the process have been worked out which provide a practicable set of instructions for shop use. The high current-efficiency and rate of deposit of the warm concentrated sulphate bath will enable the plater to complete practically any salvage job in one working day.

Strength of Materials. By S. Timoshenko. Published by D. Van Nostrand Co., Inc., New York City. Part I, 368

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pp. Price, $3.50. Part II, 735 pp. Price, $4.50. **[G-3]**

The book was written partly for teaching purposes. It is divided into two volumes. The first volume contains principally material which is usually covered in our engineering schools in required courses on strength of materials. The more advanced portions of the subjects are of interest chiefly to graduate students and research engineers, and are incorporated in the second volume of the book. This contains also the new developments of practical importance in the fields of strength of materials and theory of elasticity.

The contents of the book can be arranged for a course which treats the fundamentals of mechanical properties of materials and establishes the relation between these properties and the working stresses used under various conditions in design.

A.S.T.M. Standards. Published by the American Society for Testing Materials, Philadelphia, 1930. Price, single part in cloth, $7.50; half-leather, $17.00. **[G-3]**

This is the 1930 edition of the triennial Book of A.S.T.M. Standards. It contains the 430 Standards adopted by the Society and is issued in two parts: Part I, Metals, 1000 pp.; Part II, Non-Metals, 1214 pp.

The chapters concerning steel, iron, alloys, non-ferrous metals, preservative coatings, petroleum products and lubricants, rubber products and insulating material should be especially interesting to the automotive engineer.

Sheet Steel and Tin Plate. By R. W. Shannon. Published by the Chemical Catalog Co., Inc. New York City, 1930, 285 pp. Price, $5. **[G-3]**

The increased use of sheet steel in so many different directions has very naturally quickened interest on the part of the consumer in the processes that produce the material and the means distinguishing the different processes. These processes are described by the author in non-technical language, starting with the early history of sheet-steel making up through modern processes and finishes. A mass of technical data about sheet steel of the highest importance and interest and also specific data on how to specify sheet steel are incorporated in this book.

Standards and Specifications for Nonmetallic Minerals and Their Products. Published by the United States Department of Commerce, Bureau of Standards, City of Washington, 1930. **[G-3]**

This volume represents an attempt on the part of the Department of Commerce to collect and publish the substance of the standards and specifications relating to nonmetallic minerals and manufactures thereof, formulated by the National technical societies, the trade associations having National recognition, or other organizations which speak for industry or with the authority of the Federal Government as a whole.

Quenching of Alclad Sheet in Oil. By Horace C. Knerr. Paper presented at the meeting of the American Institute of Mining and Metallurgical Engineers, Chicago, Sept., 1930. **[G-5]**

The resistance of Alclad sheet to corrosion is much less affected by the quenching medium than is that of duralumin. It appears that Alclad sheet can be quenched in a good quenching oil, such as is used in the heat-treating of steel, without serious sacrifice of either tensile properties or corrosion resistance and with much less distortion as compared with quenching in cold water.

MISCELLANEOUS

Carbon-Monoxide Poisoning in Industry. By May R. Mayers, M.D. Published by the Department of Labor, State of New York, 1930. **[H-4]**

The first part of this bulletin is devoted to a discussion of carbon-monoxide poisoning, per se, to lay a foundation

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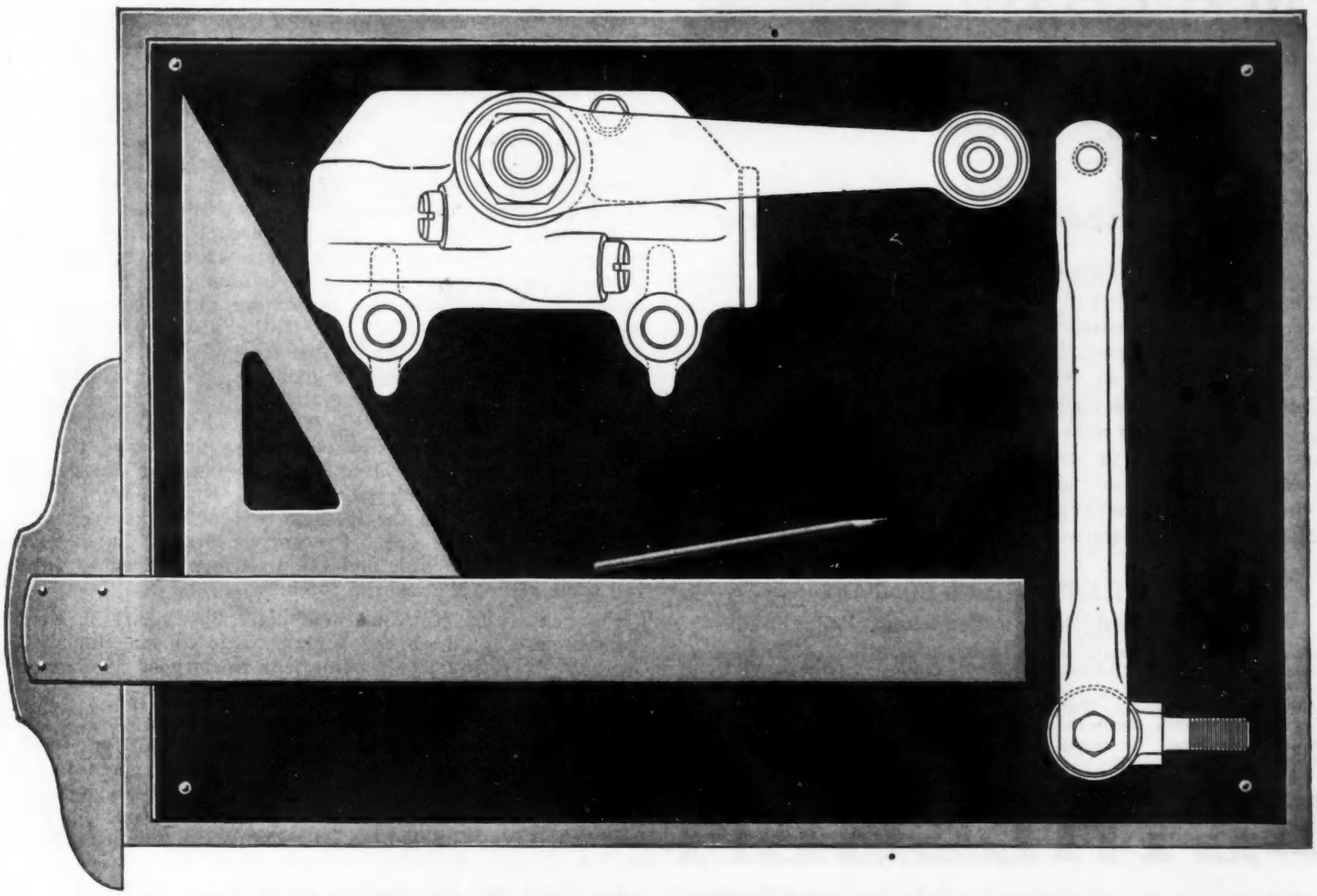

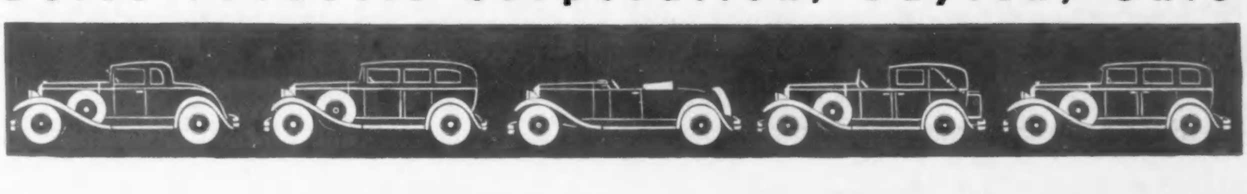

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for a consideration, in the latter parts, of the application of this information to the practical problems arising in those industries in which the presence of this gas constitutes a health hazard. Part I, therefore, deals with the illness as an entity—the physiological changes that occur in the body under conditions of exposure to carbon manaxide and precisely how these changes occur; the pathological changes, as the actual tissue-damage wrought by such exposure; the symptoms of the individual and the clinical picture he presents to the examining physician; the factors underlying the diagnosis of the disease; its clinical course and the ultimate outcome.

Part II discusses the carbon-monoxide hazard in industry, considers its sources, the practical problems of industrial control and of compensation. The fact that carbon monoxide in industry is combined with other gases and the extent to which this would tend to increase the hazards to workers are also considered.

Part III deals with the medical care of workers exposed to carbon-monoxide gas. Preventive medical supervision is particularly stressed, and the treatment of acute cases and their after care are set forth.

Fundamentals of Machine Polishing. By Robert T. Kent. Paper presented at the fourth National machine-shop-practice meeting of the American Society of Mechanical Engineers, Chicago, Sept. 22 to 24, 1930. [H-5]

The success of machine polishing depends upon the correct coordination of the variables present in the work itself, the polishing wheel, the abrasive, the machine, and in the glue used in setting up the polishing wheel. These variables are discussed in detail and their relation to one another set forth. Typical polishing machines and examples of successful machine-polishing are described.

Safety and Its Relation to Production. By James H. Maguire. Paper presented at the National Safety Congress, Pittsburgh, Sept. 29 to Oct. 3, 1930. [H-5]

The gist of this paper is that safety and efficiency in production go hand in hand. Management must be as fair in its conduct of a safety campaign as it would be in a production campaign. A safety campaign is not weakened by telling the workmen that the benefits are mutual; also that safety first does not increase manufacturing cost but actually, by improving the morale and establishing the peace of mind of the workman, increases profits.

Other papers presented at this congress that may be of interest to production men are: Foot Injuries, by John B. Gilson; Selling Safety to the Man on the Job, by I. L. Gilbert; Hand and Portable Tools, by Arthur H. Gerald; and Eye Safety in Industry, by Don M. Campbell, M.D.

MOTORBOAT

The Motorboat Section of the Olympia Exhibition. Published in *Engineering*, Oct. 31, p. 550, and Nov. 7, 1930, p. 591. [I-3]

Automobile manufacturers are finding it increasingly to their interest to produce a special model of their standard car-engine modified for marine use, thus creating competition with the older marine-engine manufacturers. The extent of this new form of competition was illustrated at the recent car exhibition at Olympia, London, where about 40 per cent of the engines shown in the motorboat section bore the names of automobile manufacturers.

Numerous airless-injection marine units, four- and six-cylinder engines, exhibited at the show are described in this article.

At present the motorboat industry offers the most promising field for the employment of heavy-oil engines of the airless-injection type, as in the past it has offered a secure market for hot-bulb engines.

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PASSENGER CAR

Engineering Problems of Modern Motor-Cars. By William G. Wall. Paper presented at the French Lick meeting of the American Society of Mechanical Engineers, French Lick, Ind., Oct. 13 to 15, 1930. [L-1]

The author is of the opinion that the many-cylinder engine is here and will probably remain, because the greater number of cylinders gives much smoother torque. Engineers are concerned over the slightly increased piston friction due to a greater percentage of piston rubbing surface, and to the difficulty in the fitting of the large number of pistons.

The speed of all engines is gradually going up, increased speed being one of the simplest ways of getting more power with the same piston displacement.

The author believes that more cars with front-wheel drive will appear in the near future, but that transmissions will revert to the three-speed type or the present four-speed transmission without the low speed.

The use of steel stampings in place of castings for such parts as rear-axle housings, front and rear engine-arms, all frame members, parts of transmission cases, brake-drums, engine oil-pans, valve covers and other pieces of this nature is playing a big part in the reduction of costs. Another factor in lowering costs is the use of interchangeable parts.

The biggest problem in the construction of reciprocating engines today concerns pistons—making them run quietly, keeping the weight down and preventing the oil from getting into the combustion-chamber. Aluminum pistons and experimental work on oil leakage have made great headway.

Piston-pins formerly were held in the pistons with set-screws, but today the practice is either to use a pin clamped by the rod and free in the piston or else a floating pin which is free to move in both the piston and the connecting-rod bearing. Experience has taught that bronze bushings are necessary in cast-iron pistons. Aluminum pistons, on the other hand, are quite satisfactory without being bushed for the pins. Today, most pistons have considerably thicker heads than formerly.

Piston-rings of innumerable designs have been placed on the market. All have some merit, although some are complicated, consisting of several pieces. The present practice is to use plain rings, either cast or hammered, for, if the pistons are properly made, almost any ring will hold the compression and keep down the oil.

The purpose of manifold design is to obtain a uniform and equal distribution of the gas to all of the cylinders. The speed of the gas through the manifold should be constant, or there should be a gradual increase of speed from carbureter to valve port. The manifold should slope either toward the valves or back to the carbureter so as to obtain proper drainage.

TRACTOR

An Economic Study of Tractors on New York Farms. By C. W. Gilbert. Published by the Cornell University Agricultural Experimental Station, Ithaca, N. Y., 1929. [M-4]

The author visited 175 farm-tractor owners in four different farming areas in New York State and obtained detailed records of the cost of operating tractors on farms and their advantages and disadvantages for farm use as experienced by farmers who have used them.

The different kinds of work done with tractors and the proportion of time spent in each operation have been listed. Plowing and fitting land for planting constitute the larger part of all drawbar work, and silo filling, sawing wood and threshing constituted the larger part of the belt work.

Figures representing the average and the annual cost of tractor operation are given. The total useful life is estimated at 8.5 years.

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Distribution of horse labor is such that the tractor will displace horses at the busiest season of horse work. There is also a promising increase in labor efficiency.

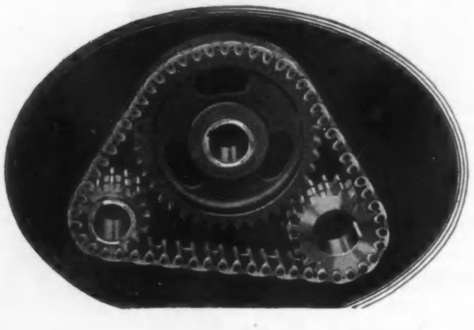
The advantages of a tractor increase with increasing size of the farm business. More efficient use of tractor labor and tractor equipment was secured with a larger farm business.

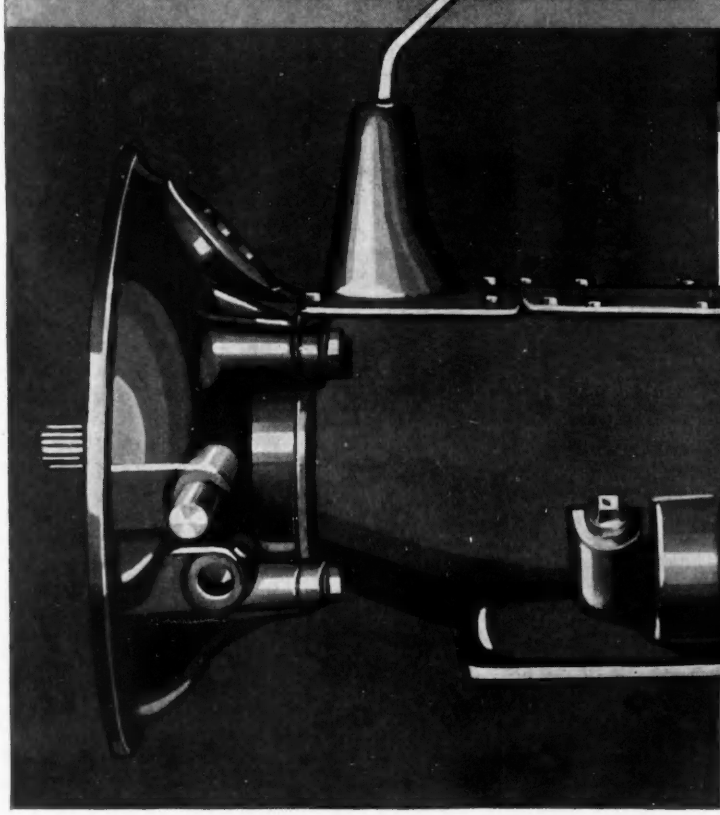
World Agricultural Tractor Trials, 1930. Published by the Royal Agricultural Society of England in conjunction with the Institute of Agricultural Engineering, University of Oxford. **[M-4]**

While this is primarily an official report, it is intended also to serve as a catalog of the tractors which have been tested and which were on view at the demonstration. The first section deals with a full description of the methods by which the tests were conducted. The report of the general tests on tractors follows, together with a brief report of the road test, a supplementary test for which only two machines were entered. The tests of market-garden cultivators are next dealt with. In the final section an illustration and specification of each machine is given, together with a brief extract from the results of its tests.

Thirty-three tractors and three power-driven market-garden cultivators were entered for the trials and reported for test. The countries represented by the tractors are as follows: United States, 10; Great Britain, 8; France, 5; Germany, 4; Canada, 2; Sweden, 2; Hungary, 1; and Ireland, 1. Of the market-garden cultivators, two are of British and the third of Swiss origin.

All the tests have been conducted by the staff of the Institute for Research in Agricultural Engineering, University of Oxford.





Personal Notes of the Members

(*Continued from p. 285*)

became assistant to the president of the Fairchild Aviation Corp., also in New York City; and the following year he was employed as engineer by the Aviation Corp. of America for a short period, preparing estimates on new routes.

Mr. Bigelow's association with Mr. Black began in 1928, with the founding of Black & Bigelow, Inc. He became vice-president of the firm, in charge of industrial engineering and assisting President Black until the latter's resignation.

Luncheon Tendered to Schildhauer

Prior to his departure for Lisbon, Portugal, on Jan. 10 to rejoin the Dornier Do-X, Lieut. Clarence H. Schildhauer was tendered a luncheon in his honor at the Whitehall Club, New York City, on Jan. 9, by F. W. Lovejoy, sales executive of the Vacuum Oil Co. Edward P. Warner, editor of *Aviation* and President of the Society in 1930, was a participant.

Lieutenant Schildhauer told of plans for the flight of the Do-X to America this winter, on which he is to be a co-pilot of the world's largest airplane. Repairs to the flying-boat, following the destruction of a wing by fire, have been made, and the take-off for the Cape Verde Islands had been set for the latter part of January. From those islands the flight is to be continued, according to Lieutenant Schildhauer, across the South Atlantic to Fernando Noronha, an island off the Brazilian coast, thence down the South American coast to Rio de Janeiro. From that city the ship will be flown north, arriving in Miami, Fla., perhaps early in March.

The Do-X is licensed for 48 tons, of which 16 tons will consist of passengers and fuel. It has a maximum speed of about 127 m.p.h. and will be cruised well throttled at 102 or 103 m.p.h. The landing speed is about 78 m.p.h. The huge flying-boat is as simple and easy to handle as the usual small airplane, according to the speaker.

W. T. Donkin, engineer of the Cleveland Wire Spring Co., of Cleveland, having recovered after a protracted illness, has returned to his active duties with that company.

J. Frank Duryea, a long-time Member of the Society and a pioneer in the industry, who has for some years been residing at Buffalo, has retired from the business world and is no longer vice-president of the Stevens-Duryea Co., of Chicopee Falls, Mass.

Fred W. Herlihy has recently been appointed sales manager of the New England district for the Shell Eastern Petroleum Products, Inc., of Boston. He formerly served that company as chief automotive engineer at its headquarters in New York City.

Announcement has been made by George C. Lees, president of the United States Axle Company, Inc., of Pottstown, Pa., that **Kenneth Howard**, secretary and sales engineer of that company, has been appointed its sales manager.

John H. Jaschka, general sales engineer of the National Malleable Steel Castings Co., of Cleveland, was recently transferred from the company's Cleveland headquarters to its St. Louis office, where he will look after railroad business as well as automotive sales. Mr. Jaschka was chairman of the Cleveland Section in 1925, and vice-chairman during the following year.

W. Laurence LePage has recently undertaken the duties of chief engineer for the Kellett Aircraft Corp., of Philadelphia, the first Autogiro licensee in this Country. Mr. LePage served on the Aircraft Committee of the Society last year and is the author of a paper, The Autogiro Analyzed, which appeared in the S.A.E. JOURNAL for September, 1930, p. 257, after its presentation at the Metropolitan Aeronautic Meeting.

George Muench has entered into partnership in the George Muench Co., of Stamford, Conn., manufacturers of special machinery and automotive specialties. He previously was superintendent of transportation of the Georgia-Florida Motor Lines, Inc., of Jacksonville, Fla.

(*Concluded on second left-hand page*)

Personal Notes of the Members

Concluded

A. H. Packer recently accepted the post of editor of *Motor Service*, a magazine published in Chicago. He was formerly connected with the Dyer Enzinger Co., of Milwaukee, as a copy writer.

F. B. Selensky has resigned his position as chief draftsman for the Climax Engineering Co., in Clinton, Iowa, and accepted a position in the engineering department of the John Deere Tractor Co., of Waterloo, Iowa.

Word has been received here that **David Sicklesteel**, formerly chief engineer with the Detroit Gear & Machine Co., has joined the engineering staff of the Muncie Products Division of the General Motors Corp., of Muncie, Ind.

O. D. Treiber is now serving the Hercules Motors Corp., of Canton, Ohio, as chief engineer of the Diesel division. He was previously president and chief engineer of the Treiber Diesel Engine Corp., of Camden, N. J.

Lewis L. Warriner is now vice-president and factory manager of the Master Electric Co., of Dayton, Ohio. Prior to his acceptance of this post, he was manager of factories for Fairbanks, Morse Co., in Beloit, Wis.

F. G. Whittington has, since Jan. 1, been engaged in the duties of chief engineer for A. Schrader's Son, Inc., of Brooklyn, N. Y. He formerly resided in Detroit.

Robert S. Winter is now an experimental engineer with the Brunswick Radio Corp., of Muskegon, Mich. His previous position was with the Freeman Motor Co., of Detroit, for which he was production manager.

Stephen J. Zand has severed his connection with the Taylor Instrument Companies, of Rochester, N. Y., which he served as aeronautical engineer, and is now serving the Pioneer Instrument Co., of Brooklyn, N. Y., a division of the Bendix Aviation Corp., in a similar capacity.